AN ECONOMETRIC APPROACH TO EVALUATING AND UNDERSTANDING ALTERNATE MONETARY TRANSMISSION MECHANISMS

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The main objective of this study is to try to understand how money affects real output. Despite the long history of this subject and the existence of several theories that try to explain how the monetary effect is transmitted to real output, there is still no consensus on how the transmission actually works. To put it in a more practical context, there is still a knowledge gap between the time the monetary policy is implemented and the time the effects are felt on real output (or inflation). In the literature this interim is dubbed the 'black box'. Using the various tool kits of the VAR system, such as the impulse response function, the forecast error variance decomposition and Granger-causality test, this study hopes to open the lid of this so-called 'black box' and see what goes on inside. In operational terms, this involves examining and evaluating the different transmission mechanisms with particular focus on the bivariate relationships within each theoretical model. Furthermore, in an attempt to follow the sequence of the causal relationships as indicated in the different monetary transmission models, two transmission modes are used: a 'serial' and a 'parallel' transmission mode. And in order to compare the overall performance of the different transmission models, composite or summary measures pertaining to the responsiveness, the explanatory power and the Granger-causal effect of each model are used—but these are still based on the bivariate relationships within each model. The analysis is initially carried out using New Zealand data but in order to see whether the results hold in other countries, the analysis is extended to Australia. One important reason why Australia is chosen is because of the divergence of the output paths of the two countries since the mid 1980s when New Zealand undertook major economic and financial reforms—before then, the outputs of the two countries seemed to move together. Because the interest is generally on money and its real effect, the empirical analysis started off with the monetary neutrality and superneutrality tests using Fish and Seater (1993) framework.

The results of the empirical analysis show fairly interesting and important insights. On the neutrality tests, the monetary long run neutrality proposition is not rejected however money superneutrality is decidedly rejected. There is also evidence from the impulse response analysis of monetary non-neutrality. This provided the logical basis for carrying out the monetary transmission analysis. The results show that each transmission model propagates the monetary impulse differently—at least there is evidence to suggest that the effects on output, in terms of timing and magnitude, are different. The importance of the credit channel, in particular the credit-consumption channel, is also evident from the analysis. Furthermore, the use of the interest rate instead of the money supply as the source of monetary impulse changes the responsiveness or the effectiveness of the transmission models. In Australia the money supply shows a fairly dominant effect on output while in New Zealand the interest rate seems to have more influence on output path, especially in the long run. This finding supports the contention that 'money matters'. Another useful insight is the lower response of fixed investment to interest rate shock in New Zealand compared to Australia. The exchange rate response to interest rate shock however is higher and more persistent in New Zealand than in Australia. The result of the counterfactual analysis in which New Zealand interest rate is modified as to follow that of Australia in the 1985-90 period shows that New Zealand would have got a higher output had it followed Australia's interest rate movements in the period indicated. These results, needless to say, have important policy implications. The introduction of the serial and parallel transmission concept and the use of the summary measures greatly facilitated the analysis.

Key words: monetary transmission mechanisms, serial transmission, parallel transmission, direct transmission, bivariate relationship, unit roots, stability, long run multipliers, vector autoregression (VAR), impulse response function, forecast error variance decomposition, Granger-causality.

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INTRODUCTION

1.1 Overview of the study

The main objective of this study is to examine and evaluate the different mechanisms by which a monetary impulse gets transmitted to real output—in the literature these processes are called: *monetary transmission mechanisms*. This topic is of great interest to both academic researchers and to policymakers. To academic researchers, this topic is actually the extension of the money-output relationship (or monetary neutrality proposition) that has caused so much debate and controversy[1] among economists since David Hume first wrote his essays *Of Money* and *Of Interest* in the 18th Century. To policymakers, understanding the mechanism is crucial for the proper formulation of monetary policies. Despite extensive studies on the issue, up to now there is still no consensus as to how the mechanism actually works, prompting some researchers to call it the 'black box'[2]. Lown and Morgan (2002) refer to it as *"one of the great mysteries of economics"*. But while there is no consensus yet on the propagation mechanism there are however useful insights that have been gained from past studies and which are now being put to practical use, one key example is the adoption of inflation-targeting by central banks in some countries—including New Zealand and Australia. This policy is based on the idea (and on empirical evidence) that money is neutral in the long-run, i.e. changes in money are fully reflected in price level in the long run hence there is no need to 'target' real output. Another important empirical finding is that short-term interest rates have significant influence on real variables (see, for example, Bernanke and Blinder (1992)) hence the use of interest rates as the monetary policy tool by many central banks these days. In the same spirit, this study will try to extract important and useful information that policymakers[3] could use or at least refer to when considering or in the process of formulating macro policies. In some sense one could view this study as an attempt to 'peek' into the so-called economic 'black box'.

[1] This is well documented in many published books, see, for example, Begg et al. (1991), Gale (1982), Hillier (1991), Levacic and Rebmann (1982), Samuelson and Nordhaus (1998), Snowdon et al. (1994), Stein (1982), Stewart (1972), among others.

[2] See, for example, Bernanke and Gertler (1995), Morsink and Bayoumi (2001).

[3] Particularly those in New Zealand and Australia.

There are several theoretical propositions that attempt to explain the monetary transmission mechanisms—Mishkin (1995) lists four main channels while the Mosser and Kuttner (2002) paper discusses six channels. However, within each main channel there are variants[4], hence the total number of possible transmission mechanisms would be more than six. This study concentrates only on four main channels, viz., the interest rate, the exchange rate, the other asset price effects (or consumption wealth), and the credit channels.

In order to have a fairly comprehensive and systematic approach to the issue of monetary transmission, the empirical analysis starts off by testing the classical monetary neutrality and superneutrality propositions. These preliminary tests may be considered as an attempt to answer the more fundamental question: Does money affect real output? After this, the estimation and evaluation of the different transmission mechanisms is undertaken using New Zealand data. The important issue here is: How does money affect output? This is followed by a similar analysis on Australian data with the intention of comparing the transmission mechanisms between the two countries. This will not only provide useful information about the institutional settings or unique characteristics of the two economies but may also provide an explanation as to why New Zealand output path levelled off in the mid 1980s while Australia's output continued almost uninterrupted in the same period. The question of interest is: Can the monetary transmission mechanism explain this divergence in output paths? To specifically answer this question, a counterfactual experiment is conducted in which New Zealand interest rates are modified to follow that of Australia—this is the last part of the empirical analysis.

The empirical part of this study is based on the vector autoregression (VAR) framework[5]. In particular the VAR's innovation accounting tools, such as the impulse response function and the forecast error variance decomposition, as well as the Granger-causality test, are the main tools in the analysis. The advantage of this approach is that it allows interactions and feedbacks from all variables within the model, i.e. this avoids the problem of having to choose which variables are exogenous or endogenous[6]—a common problem facing

[4] For instance, instead of fixed investment one could use private consumption expenditure.

[5] The VAR framework is widely used to study the transmission mechanism. For instance, in their paper, Mojon and Peersman (2001) said: *We use VAR models, which is the most widely used empirical methodology to analyse the transmission mechanism.*

[6] This is aptly illustrated by Jha and Donde (2001) when they said, *"For example, in our analysis, it would be*

economists since no consensus has ever been reached as to how the economy is to be modelled. Another important feature of the VAR is that it allows, through its vector moving average form, a direct relationship between exogenous shocks and the endogenous variables. The use of the lagged values is also consistent with the fact that the effects of policy decisions take time to be felt in the economy[7], i.e. the system provides a dynamic nature that is very important for simulation and policy analysis. Furthermore, the reduced form of the VAR is consistent with the rational expectation theory[8].

In addition to the VAR tool kits that have been mentioned above, other useful analytical constructs, like the long run derivative of Fisher and Seater (1993) and the summary measures of the transmission mechanisms are also used in the analysis. These summary statistics are intended to compare the 'responsiveness' or the 'effectiveness' of the different transmission models. Another novelty introduced into the analysis is the idea of viewing the transmission process as consisting of two main modes: 'serial' and 'parallel' transmission modes—this is a concept from physics and is considered useful here because it provides a logical and systematic approach to studying the transmission mechanisms.

A distinguishing feature of this study, which is slightly different to most other empirical studies, is the preferred use of the actual unadjusted data series[9] wherever possible. Only when serious estimation failure occurs because of the nature of the 'raw' data will appropriate adjustment or transformation be performed. One motivation for this is the fact that most studies done in the past, because of the extensive adjustments made on the data, are often difficult to interpret or understand. In many instances, this leads only to qualitative interpretations that are not very helpful to policymakers. This is unfortunate

incorrect to hypothesize that the Fiscal deficit causes money supply, but in turn is not affected by it. We thus used a framework in which there is no apriori endo-exogenous division of variables. The natural outlet for this is a VAR".

[7] The lag effects of government policy is well articulated in Uselton (1974). And in their introduction, Mahadeva and Sinclair (2002) point out that: *A central bank's interest in the transmission mechanism of monetary policy arise from the fact that it takes time for monetary policy to exert its maximum impact on inflation.* This implies that accurate information on the lag-period is required.

[8] Before this the 'adaptive' expectation model was very popular but as explained in Thomas (1993, p. 127), the rational expectation model superseded the adaptive model because of some serious deficiencies noted in the adaptive model.

[9] This means leaving the data seasonally unadjusted and in the original units (i.e. not transformed to logarithmic values).

because after all the extensive and complicated analysis that had been done, only a few can read and understand the results. Hopefully this drawback will be avoided in this study.

Data from New Zealand is used because this is where this study is undertaken—and Australia provides an interesting reference point because of the similarity in the output paths of the two countries before the introduction of the economic and financial reforms in both countries[10] in the mid 1980s. Also the proximity and substantial interactions, both in terms of trade and comovements of people between the two countries, make the comparison interesting.

1.2 Outline of the Thesis

Chapter 2 reviews the monetary transmission theory while Chapter 3 contains a review of past empirical studies on neutrality and monetary transmissions. The econometric issues are discussed in Chapter 4. Chapter 5 outlines the methodology and the modelling strategy and Chapter 6 and Chapter 7 both contain the analysis and the results. The study's policy implications, its limitations and suggestions for future research, as well as a brief concluding statement, are all grouped in Chapter 8.

[10] For details of the reform in New Zealand see Dalziel and Lattimore (2001). Scollay et al. (1993) also contains useful references about the reform process in New Zealand.

Chapter 2

MONETARY TRANSMISSION THEORY

2.1 Introduction

Although the concept of 'monetary transmission' may have been around since monetary theories were first developed[1], the use of the specific term 'monetary transmission' was more recent. In fact, as recent as 1999, Bennett McCallum referred to the varied meaning of the term used by several authors and said, *"More generally, many writers on the subject restrict their attention to the effects of monetary policy shocks, while some are concerned only with effects on real variables"*[2]. In any case because 'monetary transmission' is basically an extension of monetary theory, it is necessary to start off the discussion with standard monetary concepts and theories. These should provide some theoretical basis for understanding the transmission mechanism at work, even though it is important to emphasise that there is still ongoing debate on this subject—as Plosser (1989)[3] said, *"The role of money in an equilibrium theory of growth and fluctuations is not well understood and thus remains an open issue"*.

Monetary theory is a vast and complex field and a single chapter on it cannot do justice to the long and extensive evolution of great thoughts, including periods of bitter and controversial debate[4], that have gone into its formulation into one of the main, if not the most important, branches of contemporary macroeconomics. This is not to say that eventually a single and acceptable consensus has been reached—in fact, there still remains, though in a slightly different form, mainstream debate between the New Classical (real) equilibrium business cycle theorists and the New Keynesians (Snowdon et al., 1994, p. 42). This diverse and disparate view of monetary economics is somewhat captured in Gale (1982, p. 3) when he said, *"There are several reasons for not attempting an encyclopaedic*

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[1] As embodied in the classical quantity theory of money or in the IS-LM framework of Keynes.

[2] See McCallum (1999).

[3] As cited in Snowdon et al. (1994, p. 255).

[4] Initially the debate was between Keynes and the classical economists in the 1930s, then later in the mid 1950s to 1960s, the Monetarists, in particular Milton Friedman, attempted the re-establishment of the 'quantity theory of money' approach in the macroeconomic analysis (see for example, Friedman (1995), Snowdon et al.,1994, p. 138). Interestingly, the more recent real business cycle theorists claim that *money has no systematic relation to any real variable at any time* (see Brunner and Meltzer, 1990) while the New Keynesian models include interest rate--a kind of turnaround process given that initially the 'Classicals' (in particular the Monetarists) argued for an important role of money in setting policies while 'orthodox' Keynesians assign low priority to money.

treatment. .... monetary economics lacks a single "paradigm" which is adequate to describe the disparate phenomena that involve money in an interesting and essential way. Different models and different analytical methods are used to study a wide variety of theoretical problem; but they all have a claim to be included in the corpus of monetary theory". In other words, the nature and scope of monetary theory is too wide and too diverse and consequently it would be extremely difficult, if not impossible, to cover adequately the subject in a single chapter like this. In view of this some bias selection will have to be made here of the topics to be included and discussed. Naturally the first part of the discussion will focus on the nature and definition of money including the role of the banking system. After this the discussion on some theoretical models linking money and real output will be made and lastly, we will look at the transmission theories, in particular the more common transmission models like the traditional interest rate, the exchange rate, and the credit models.

2.2 What is money?[5]

Money in its basic and more understood form is a 'medium used to facilitate exchange of goods or services'—i.e. a convenient mechanism used to avoid the inherent problem of 'double coincidence of wants' in a barter system. Keynes (1930, p. 3) refers to it as: *Something which is merely used as a convenient medium of exchange on the spot may approach to being money, inasmuch as it may represent a means of holding general purchasing power,* and Galbraith (1975, p. 5) describes it as: *What is commonly offered or received for the purchase or sale of goods or other things.* Mishkin (1998, p. 9) gives a more concise definition of money: *anything that is generally accepted in payment for goods and services.* Stressing the economist's interpretation Mankiw (1998, p. 314) said, *"Money is the set of assets in the economy that people regularly use to buy goods and services from other people".* A totally different but interesting definition of money is given by Guttmann (1994, p.19), *"Money is a social institution subject to historic evolution. Its modus operandi varies according to period and place. This is even true today".* The use of the words: 'something', 'anything', 'set of assets', and 'institution' is unfortunate because it creates the ambiguity and the 'open-ended' classification that makes it hard to define exactly the term 'money'—this poses problems to theoreticians as well as to empirical

[5] A useful discussion of the origin and the evolution of money can be cited in Dalziel (2001) second chapter.

researchers[6], and this could be one reason why it is so difficult to get a single acceptable monetary theory.

In modern days, money is generally comprised of bank notes, coins, and checking deposits, and possibly deposits that are close substitutes for currency (Dwyer and Hafer, 1999), but in the distant past money would have been some form of precious metals[7], tobacco or simply sea shells. The terms often given to these different forms of money are: commodity money, fiat (token) money, and bank deposits. Obviously commodity money is no longer important these days however it is interesting to note Guttmann (1994) claim that there had never been 'true' commodity money throughout modern civilizations—even gold and silver coins were actually 'tokens'[8]. Keynes (1930) also talks of commodity money and fiat money but on the third category he used the term, 'managed' money. This category, which Keynes defines as a hybrid between the other two well-known categories, is not very clear[9] and is difficult to find an equivalent or close representation in the monetary literature. Keynes has another money category which he calls 'bank money' that is more consistent with the banking deposit or 'credit' money commonly cited in the monetary literature (see, for example, Guttmann (1994) and Dalziel (2001)).

Fiat money, Keynes (1930, p. 7) says, *"is representative (or token) money, (i.e. something the intrinsic value of the material substance of which is divorced from its monetary face value)—now generally made of paper except in the case of small denominations—which is created and issued by the State, but is not convertible by law into anything other than itself, and has no fixed value in terms of an objective standard"*. This summarises the current nature of bank notes showing clearly the important role of the State as the main issuer which by implication means the government has direct control on the supply of this type of money. This is different to credit money that is created by the action of the banking sector

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[6] The empirical problem is stressed by Thomas (1993, p. 350) when he said, "*While at the theoretical level it may be quite appropiriate to talk about 'money' in a very general sense, for empirical work a precise definition is obviously necessary if required data series are to be obtained*".

[7] For example, Galbraith (1975) listed silver, copper and gold.

[8] Guttmann (1994, p. 30) argues strongly against the classical treatment of money as a commodity and declares, *"We do not live in a barter economy, and our prevalent form of money is certainly not a commodity that comes out of a regular production process. Today we operate in a regime of credit-money, whose characteristics escape the majority of economists still fixated on defining money as just another good "*.

[9] In fact, Keynes (1930) himself admitted the difficulty by saying (p. 9), *"Thus managed money is in a sense a hybrid between the two; and, perhaps for this reason, its qualities are not so easily understood"*.

when extending loans on the basis of their deposit reserves[10]. This is an important issue because it could mean a weakened role of the monetary authority in conducting an effective monetary policy. As Dalziel (2001) in his first page points out, *"The difficulty is that virtually all money in modern economies takes the form of bank deposits that are created, not by the monetary authourities,. but by the credit extension activities of private banks. Consequently, central banks are able to influence the volume of this credit-money only indirectly, particularly through policy-induced changes in the banking system's base interest rate"*. Guttmann (1994) gives an even lesser role to the central bank by saying (p. 33), *"The central bank controls only the excess reserves that enable banks to create new money. It does not control the willingness of banks to lend out these excess reserves. ..... Finally, the central bank does not control the public demand for bank loans"*. The significance of this issue is well illustrated in Paul Volcker (2002) Address to the Federal Reserve Bank of New York and the Federal Reserve Board: *When the central bank tries to restrain, the natural instinct is to find some way round it, to find money substitutes and new political instruments less directly under the influence of the central bank. If they cannot find the way economically, they will look for it politically.* He continued on and said, *"So it seems to me—and I say this with some tentativeness—that the market is going to try to minimize the use of the 'base money', the one thing the Fed controls. If no interest is paid on base money, market participants will try to minimize the need to hold reserves or currency, or develop other payment systems, once again trying to work around any constraint set up by the central bank"*. Obviously the possibility of the banking sector or the markets to find ways of circumventing what the central bank does in order to meet its liquidity requirements, shows another feature of money—namely as an institution that can change or evolve according to circumstances, in line with the description of money by Guttmann (1994) as indicated earlier.

Based on the foregoing discussions we see that whilst money can be any 'medium' that the state or the monetary authority[11] issues out in order to facilitate the exchange of goods and services, it is also becoming quite clear that the ability of the banking sector and the markets in general to create 'new money', or money substitutes, could undermine the monetary authority's role in influencing the economy. However, looking at this issue from

[10] This is known also as 'fractional-reserve' banking.
[11] Usually the central bank or the government itself.

the banking sector perspective, Guttmann (1994, p. 33) says, *"This ability to add liquidity gives banks a much more important role in our economy than their reduction to the status of intermediaries in standard economics would imply"*. In fact many empirical studies have confirmed the importance of the bank credit transmission channel[12] —in addition to the traditional interest rate and the exchange rate channels (these will be discussed in more detail in sub-Chapter 2.4).

Having discussed the nature and the form of money, the next problem is to actually define money in a way that is consistent over time and meaningful for analytical purposes. Obviously this is an empirical issue—as Mishkin (1998) points out, there is no precise definition of money supply because it depends on the classification and aggregation[13] of other assets that could be substituted for 'money proper'—such as bank deposits, bank savings, etc. Though there may be slight differences in the definitions from country to country, the following monetary aggregate definitions are currently used by the Reserve Bank of New Zealand[14].

Currency	=	*notes and coins on issue from the Reserve Bank*
M1	=	*currency + checkable deposits*
M2	=	*M1 + all non-M1 'call funding' (includes overnight money and funding on terms that can of right be broken without break penalties)*
M3	=	*all New Zealand dollar funding of M3 + Reserve Bank repos with non-M3 institutions. This is the broadest aggregate, i.e. includes M2 as well.*

Other important definitions[15]:

Monetary base (H)	=	*Currency (C) + Bank reserves (R)*
Money supply (M)	=	*Currency or M1 or M2 or M3*
Money supply (M)	=	*Money multiplier x Monetary base (H)*
Money multiplier	=	*Money supply (M)/ Monetary base (H)*

Note: Monetary base is also called the 'central bank money' or 'high-powered money'.

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[12] As noted in Estrella (2002) opening statement: *While there is no prevailing view of the monetary policy transmission, the credit markets are important in practically every mainstream view.*

[13] On the aggregation issue, critics of Friedman claimed that he arbitrarily aggregated different definitions of money in order to back up his claim that shrinking monetary aggregates caused the recessions (see Krugman, 1994). And on the definition of money, Peterson (1996) says, *"The proper definition of money remains an unsettled issue. Basically, this is an empirical question...."*. And in their comment on Chetty (1969) paper "On Measuring the Nearness of Money", Steinhauer and Chang said, *"If such a measure could be found, then one could use it to construct a better money supply total"*. All these reflect the fact that proper money measure or definition is a difficult and problematic issue.

[14] Extracted 1 October 2003 from the Reserve Bank of New Zealand webpage: http://www.rbnz.govt.nz/statistics/monfin/C1/notes.html

[15] Taken from Blanchard (1997, p. 93-97).

Having explained what is money and having looked at its different definitions, the next section will look at its specific functions. Of course these are closely related because the representation of the monetary concept was made as to ensure that the desired functions could be achieved. As Guttmann (1994, p. 22) puts it, "*the central position of money emerges only when we take a closer look at what lies behind its so-called functions*". And in a more specific and explicit statement, Orphanides and Solow (1990) say, "*In order to make sense out of any theory attempting to examine the possible effects of changing the level/rate of growth of money on real variables, one must explain the very existence of money in the economy. Why are people willing to hold money and what is its function?*" These issues will be considered below.

In the standard monetary theory, there are generally three functions assigned to money: as 'unit of account', 'store of value' and 'medium of exchange'. The first function allows otherwise heterogeneous commodities to be commensurable in terms of money-prices. The second function facilitates intergenerational transfers, i.e. provided it does not get devalued by accelerating inflation, money preserves purchasing power over time. And the last function—namely, as a medium of exchange, avoids the barter exchange problem of 'double coincidence of wants'. However in postulating different monetary theories, economists sometimes extend the functions or the roles of money in order to facilitate their models and this is why conflicting or ambiguous results arise from alternative theories, i.e. because of the different hypotheses about the functions of money (Dornbusch and Frenkel, 1973)[16].

2.3 Money, Output, and the Controversy

With some ideas now of what is money and what are its functions, our next discussion will focus on its relationship with real output[17]. Needless to say, this is an important section because this relationship has been the centre of controversy ever since Hume first wrote his essays on *Money* and *Interest* in 1752. Basically the issue is that while some reckon that money affects real output, others think it has no effect, i.e. neutral[18]. Then there are those

[16] As cited in Orphanides and Solow (1990).

[17] In the literature, there are other important relationships such as money and inflation, money and interest rate, etc. but the focus of this paper is more on money and real output.

[18] This is the classical hypothesis embodied in the quantity theory of money. A well articulated exposition of the neutrality and superneutrality of money can be cited in Patinkin (1989).

who argue that money can affect real output in the short run but not in the long run. Still others talk of unexpected (or unanticipated) money having real effects while the systematic portion does not—a rational expectation outcome. And more recently, some monetary models[19] ignore the monetary aggregates all together and instead use only the interest rate (see, for example, McCallum (2001)). As a matter of fact, the great debate between Keynes and the Monetarists that started in the mid 1950s revolves around the issue of money and its effect on real output. So while the issue, on the surface, seems quite straightforward, there are substantial and complex theories and arguments underlying the issue. The following discussions will try to summarise some of the important views on this issue, particularly from the standpoint of the different major macroeconomic schools of thought—such as the Classicals, Keynesians, and the Monetarists. It should be emphasised, however, that these major schools have further subdivisions or variants that have their own interpretations as well, such as the New Classicals, the New Keynesians and Post-Keynesians.

First it is important to point out that even Hume himself was faced with the dilemma of having to admit both the 'neutrality' of money and its 'non-neutrality'. For instance, one of his paragraphs goes like this[20]:

> It is indeed evident that money is nothing but the representative of labour and commodities, and serves only as a method of rating or estimating them. Where coin is in greater plenty, as a greater quantity of it is required to represent the same of goods, it can have no effect, either good or bad....

The above statement clearly highlights the inconsequential impact of money, i.e. money's neutrality. Now let us see Hume's other writing:

> When any quantity of money is imported into a nation, it is not at first dispersed into many hands but is confined to the coffers of a few persons, who immediately seek to employ it to advantage. ... The farmer and gardener, finding that all their commodities are taken off, apply themselves with alacrity to raising more. .....It is easy to trace the money in its progress through the whole commonwealth, where we shall find that it must first quicken the diligence of every individual before it increase the price of labour.

[19] Such as the new-Keynesian models or that of the central banks. The real business cycle school, on the other hand, holds a fairly strong view of no monetary effects whatsoever on real activities.

[20] As cited in Lucas (1996) *NobelPrize Lecture.*

This second statement implies there is at least a short-term impact of money on real output, i.e. money is non-neutral. Obviously these two paragraphs of Hume give two conflicting roles or effects of money and one can argue therefore that the controversy actually started with Hume himself. As noted by Lucas (1996), *"This tension between two incompatible ideas—that changes in money are neutral units changes and that they induce movements in employment and production in the same direction—has been at the centre of monetary theory at least since Hume wrote"*. It is interesting to note here that Lucas in fact looked at the same issue in the 1970s and in his 1996 Nobel Prize Lecture he said, *"So much thought has been devoted to this question and so much evidence is available that one might reasonably assume that it has been solved long ago. But this is not the case: It had not been solved in the 1970s when I began my work on it, and even now this question has not been given a satisfactory answer"*. Lucas continued on and claimed evidence of monetary neutrality from the 45-degree line graph of money growth against inflation rates from 110 countries. He said, *"Indeed, how many specific economic theories can claim empirical success at the level exhibited in figure 1?"* However, as pointed out by Bullard (1999), the specific evidence of monetary neutrality presented by Lucas is not strictly applicable to the concept of long run monetary neutrality that requires a permanent unexpected change in the level of money supply and the ultimate impact of such a change. A successful test that incorporates this concept was first introduced in Fish and Seater (1993) paper.

In order to discuss money-output relationship (including monetary neutrality) in a more formal manner, it is necessary to start off with the quantity theory of money[21], a classical tautology that Monetarists have used as their 'workhorse' in presenting their classical 'monetary' views, including their claim that 'inflation is essentially a monetary phenomenon propagated by excessive monetary growth'[22].

There are two main classical versions of the quantity theory formula—one is the Cambridge cash-balance (money-demand) approach and the other is the Irving Fisher income exchange formula. The Cambridge formula is presented first:

[21] Often shortened to just 'quantity theory'.
[22] Discussed in Snowdon et al. (1994, p. 159).

$$Md = k\,P\,Y \tag{2.1}$$

Where Md = nominal money demand
k = proportion of annual national income that firms and households wish to hold
PY = national money income (or nominal output)

What this formula says is that, assuming k is fixed, money demand is always proportional to nominal output, i.e., there is no mechanism here for money to cause price to increase because money is never in excess—it responds only to the demand force of the economy[23]. So in order to see how price can increase in the model, money supply (Ms) is introduced, and in equilibrium, supply equals demand:

$$Ms = Md \tag{2.2}$$

So substituting into (2.1), we get

$$Ms = k\,P\,Y \tag{2.3}$$

With the assumption that k and Y are fixed, then any increase in money supply will be matched by a one-to-one increase in price level (P). In the words of Snowdon, et al. (1994, p. 57), *"With k and Y constant, M determines P"*. In this formulation, money is said to be exogenous, i.e. the monetary authority can control its supply, whereas in the first formulation, Equation (2.1), money is endogenous. The question of whether money is endogenous or exogenous is a contentious issue and no consensus has been reached on this. In fact this issue is very much related to the ongoing debate of whether monetary policy has any real effect and there is extensive literature on this. This topic will be explored further in the monetary transmission theory section. For now we will carry on discussing the second version of the quantity theory, called Fisher's exchange version:

$$M\,V = P\,Y \tag{2.4}$$

or

$$P = (MV)/Y \tag{2.5}$$

where M = money supply
V = velocity of money (represents average number of times unit money changes hands in final transactions)
P = price
Y = real output
PY = nominal output

[23] In the words of Arestis and Sawyer (2002), *"The stock of money is determined by the demand for money, and as such it acts essentially as a residual in the sense that it does feed back anywhere to the economy".*

It is quite clear from Equation (2.5) that price (P) is dependent on nominal money supply (M) if we assume velocity (V) is an institutional factor that takes time to change and real output (Y) is fixed. Further demonstration of how this classical model works, in terms of how price is set while real variables do not change can be seen in Snowdon et al. (1994, p. 58). However it should be pointed out here that in terms of the monetary transmission subject, which is the objective of this study, the prediction of the classical quantity theory just described seems to focus on price increase only, i.e. the two formulations of the quantity theory above simply try to explain how the increase in money supply can cause price to increase proportionally—which is simply the statement of the monetary neutrality proposition. In other words, how money can influence real output is not explained. Friedman (1995), on the other hand, largely in response to Keynes revolutionary attack on classical economics, tried to re-establish the importance of monetary economics using the same quantity theory but with a slightly different form and explanation. This is summarised below and is interesting in that it tries to explain how real variables can be affected by monetary changes, i.e. we are now seeing a shift to real output.

$$\frac{Md}{P} = f(Y^p, r, \pi^e, u) \tag{2.6}$$

where $\frac{Md}{P}$ = real money balance

Y^p = permanent income or wealth

r = return on financial assets

π^e = expected inflation rate

u = individual's tastes and preferences

As shown in the above equation, Milton Friedman stresses the demand for real money balance rather than nominal money[24]. The variables that influence the demand include income, expected inflation, return on other assets, and some other factors[25]. So unlike equations (2.1) and (2.4), where the variables refer to the country as a whole (i.e. national aggregates), Equation (2.6) refers to individuals whose wealth is divided among money, other financial assets and real assets. The basic assumption here is that individuals want to maximize their wealth among different assets, meaning that they constantly monitor the rates of return on each type of assets, including money asset. So when the central bank increases money supply to the public by purchasing government securities in the open

[24] Walters (1973) also argues that what gives money importance is the amount of goods and services it can buy, i.e. it is the real money balance that matters.

[25] The actual specification and the definitions of his money demand model can be seen in Friedman (1995).

market, individuals will accordingly react to this by reducing their money holdings, say by purchasing real assets in order to retain their initial and 'preferred' wealth equilibrium[26]. This asset portfolio adjustment, in the words of Snowdon et al. (1994, p. 139), *".... is central to the monetarist specification of the transmission mechanism whereby changes in the stock of money affect the real sector".*

So with respect to the discussion above on the quantity theory, one gets the impression that one can come up with totally different conclusions from basically the same formula by using different assumptions. In fact as Friedman (1995) says in his closing remark: *One thing is certain: the quantity theory of money will continue to generate agreement, controversy, repudiation, and scientific analysis, and will continue to play a role in government policy during the next century as it has for the past three.*

Now having discussed the basis of the monetarist school and the neutrality proposition—namely the quantity theory of money, the next task is to look at the other theories that attempt to explain the relationship between money and real output. In fact what Sidrauski (1967) said about the lack of growth models that incorporate monetary factors is still very true today as there are still not many models that link nominal money directly to real output—apart from Tobin (1965) framework that tries to link monetary factors with capital intensity.

Our next discussion is on the Keynesian IS-LM framework that shows how interest rate can affect real output. There is some irony here because despite Keynes anti-monetary stance, arguing that only autonomous fluctuations in investment and consumption that cause changes in output, his IS-LM framework[27] has been used in most macroeconomic standard texts to explain how a monetary factor, like interest rate, can affect aggregate demand or output—this process is called the *Keynes effect*[28]. Keynes even introduced two situations that he was certain money would be useless even to affect investment—these are the liquidity and investment traps. In the former any increase in money would only end up as

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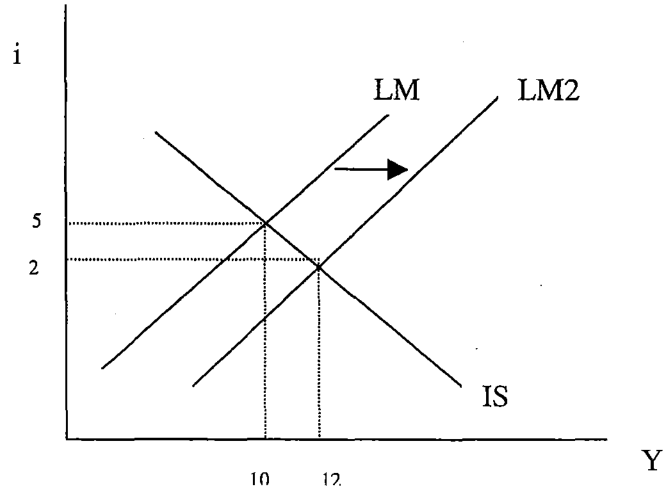
[26] This is because an increase in money supply will drive down interest rate which in turn will cause prices of other assets to rise.

[27] Actually it was Hicks (1937) who formulated the IS-LM framework based on Keynes's ideas (as cited in Hillier, 1991).

[28] See, for example, Mankiw (1998, p. 411).

idle/speculative balances while in the latter, investment is insensitive to interest rate (i.e. completely interest-inelastic). However this extreme position of Keynes has been strongly contested by Monetarists and later researchers (see for example, Levacic and Rebmann, 1982). To briefly explain the transmission based on the IS-LM framework, Fig 2.1 is presented below to facilitate the exposition (the numbers are just to facilitate the exposition).

Fig 2.1: IS-LM Model



According to the IS-LM model above, when there is an exogenous increase in money supply, say when the government purchases securities in the open market, the LM curve shifts to the right causing interest rate to decrease to 2 per cent while output increases to 12. If money supply decreases, the opposite occurs, i.e. interest rate increases but output declines. How good this model is in explaining real world phenomena is an empirical issue but so far there has been some evidence to support the model's prediction. For instance, Blanchard (1997, p. 123), in reference to the impulse response graphs of real output, inflation, and a few other variables to an increase in federal funds rate, says, *"Figure 6-13 is comforting. It shows that the implications of the IS-LM model are consistent with what we observe in the economy"*. However he cautioned though that this does not prove that the IS-LM model is right, but it shows that there is potential for the IS-LM model to explain the linkages between monetary impulses and real output.

Having explained the Monetarists and the Keynesian approaches in linking money to real output, we will next look at the New Classicals approach. There are three basic underlying assumptions of this approach: agents are rational; there is continuous market clearing and output fluctuations (from the natural level) result from unexpected or surprise inflation—otherwise output will remain at its natural level. This last assumption can be represented as:

$$Y - Y_n = \alpha(P - P^e) \tag{2.7}$$

where Y = actual or observed output
Y_n = natural level of output
P = actual price level
P^e = expected price level

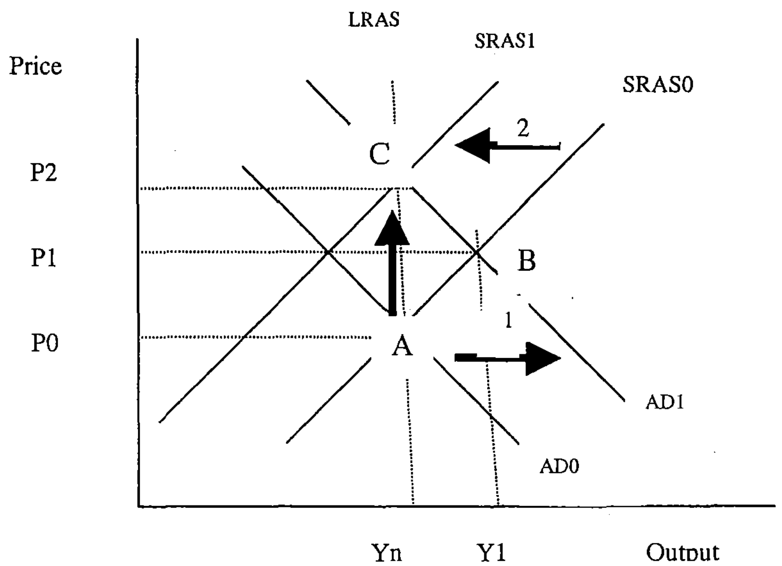
As Snowdon et al. (1994, p. 197) point out, there are several implications of these assumptions but for our purposes we will focus only on those that involve money and real output, one of which is the policy ineffectiveness[29] implication (see Fig 2.2). This proposition states that given that agents are rational, they will try to do some 'rational' reaction following government new policy that will return them to their original (natural) equilibrium production level. In Fig 2.2, for instance, when the government wants to increase output (or lower unemployment) by expanding money supply, the lower interest rate will cause greater investment spending, i.e. the aggregate demand curve (AD0) will shift to the right (arrow 1) but the rational agents, having anticipated the change, would have raised money wages to counter the higher price, leaving the level of output as before. In this instance, money is superneutral. This is shown by arrow 2 moving to the left to counter the shift in aggregate demand. In fact because of the continuous market clearing and the rationality assumptions, the change in price is instantaneous, i.e. the price just moved from P0 to P2 along the long run supply curve (LRAS) leaving output unchanged at Yn—hence the term 'policy ineffectiveness'.

So we see that if the market knows what the government plans to do, it can prepare and react accordingly to the change thus negating any intended effect. Now suppose there is a sudden unexpected policy change, i.e. people are not made aware of this policy change. In this case, when aggregate demand increases (i.e. shifts to AD1 in Fig 2.2) because of 'unexpected' increase in money supply, the market will produce at higher level (Y1)

[29] In the literature it is sometimes referred to as Sargent-Wallace policy ineffectiveness proposition.

thinking there is genuine increase in relative prices. However, the New Classicals argue that this is a temporary phenomenon because once the market knows that there is no change in relative prices, i.e. all prices (including wage rates) increase proportionally, then they will revert to their natural production level at Y_n (i.e. by shifting the aggregate supply function to SRA1).

Fig 2.2 Policy ineffectiveness proposition



In summary the New Classical approach implies that if the government increases money supply and the market had known earlier of this policy, then there will be no change to real output though the price will increase to P2 in equal proportion to money increase—as hypothesized in the quantity theory long run result. An unanticipated (or shock) increase in money however will have a short run effect on real output—unlike the Monetarist case that does not distinguish between anticipated or unanticipated increases in money supply.

It is clear that the policy implication of the New Classical approach could be quite serious in terms of monetary policy, i.e. it implies that a well-planned monetary policy could be ineffective in terms of raising output. Putting it another way, only an 'unexpected' inflation could cause a short run Phillips curve.

It is important however to point out here that despite the appeal of the New Classical approach, some serious criticisms were made against it. One is the 'rationality' assumption and the other is the use of the 'continuous market clearing' assumption that effectively rules out the introduction of 'sticky' prices in the model. Another challenge to the model came about when results of some empirical tests did show that anticipated changes in money supply (or monetary policy) have real effect as well[30]. To counter or overcome these criticisms, the real business cycle theory is developed by Edward Prescott, Finn Kydland, among others[31], in which there is no role for monetary shocks in the business cycle. As pointed out by Brunner and Meltzer (1990), *"Others, most recently real business cycle theorists, claim that money has no systematic relation to any real variable at any time".* Basically this theory argues that only supply-side shocks in the form of random changes in technology accounts for the business (output) cycle. And in order to account for the high correlation between money and output as observed in many economies, King and Plosser (1984)[32] attributed it to the endogenous response of money to output—obviously contradicting the Monetarists assertion that money supply is exogenous. In terms of the quantity theory, this would mean reading Equation (2.4) from right to left, i.e. the causal direction is from output to money—this is often known as 'reverse-causality'.

One of the fundamental problems faced by the different schools of macroeconomics is in trying to give an explanation as to why money is not neutral. The New Keynesian model takes this into account and considers the non-neutrality of money as arising from 'sticky' prices, i.e. prices adjust slowly after disturbances—unlike the continuous market clearing assumption of the New Classicals which effectively rules out the slow 'adjusting' price process. And as to the reason for sticky prices, the New Keynesians suggest real market imperfections as the cause of it. It is useful to note also that this New Keynesian model does not consider the source of shock as important—instead it considers the response of the economy to the shocks as more important.

There are several theories proposed by the New Keynesians to support the 'sticky price' assumption, but basically it all comes down to the slow adjustment of the economy to

[30] See, for example, Mishkin (1980) and Jha and Donde (2001).
[31] The names of other people involved in the development of the real business cycle theory can be seen in Snowdon et al. (1994, p. 237).
[32] As cited in Snowdon (1994, p. 254).

disturbances, i.e. there is rigidity or friction in the economy. Unlike the earlier Keynesian IS-LM model that has no firm micro-foundations, this time the New Keynesians tried to correct this by relating the price sluggishness to the behavior and decisions of the firms. For instance, they talk of long-term wage contracts of the firms that could cause the wages to adjust slowly to disturbances thus enabling the government to influence the economy through demand management, such as expanding money supply. They also blame the cost of price adjustments (i.e. menu cost) as causing price rigidity. Here they consider the 'imperfect' market[33] as operating rather than the competitive perfect market assumption of the Classicals. However, as with all other macroeconomic models, there are criticisms made against this new Keynesian approach. These include the vast array of theories intended to explain wage and price rigidities; the costs of price adjustments is not that large to account for major contractions or expansions of output; the acceptance of the rational expectations hypothesis; and so forth. Despite these criticisms, supporters of the New Keynesian model insist their model is able to adapt to both the theoretical innovations and new empirical findings, but as Snowdon et al. (1994, p. 330) say, *"It remains to be seen how successful the rehabilitation of Keynesian economics will be".*

Another important contribution to monetary theory is that of the Post-Keynesians who insist that in the modern credit-economy, money supply is endogenous, i.e. the banking sector is seen as responding to the needs of the economy by supplying the required liquidity[34]. In other words, money supply is fully elastic—a feature which Guttmann (1994) argues as providing the economic system of the United States with greater flexibility and stability. The implication of elastic money is that it responds to inflation rather than the cause of inflation—an assertion that obviously contradicts the Monetarists basic contention that money leads inflation. Another interesting implication of this approach is that it is possible to obtain full employment with an appropriate and sustained income policy.

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[33] When interviewed in February 1993, Gregory Mankiw said, *"A large part of new Keynesian economics is trying to explain why firms set the prices that they do. Firms that have some ability to set their prices are those firms with market power: they are imperfectly competitive. Imperfect competition is therefore central to new Keynesian economics* (see Snowdon et al.,1994, p. 336).

[34] This should in general mean that there will be no excessive money in the economy therefore money in this instance is not the cause of inflation—however Dalziel (2001) proposes a model in which credit-money can create inflationary pressure. Another interesting feature of Dalziel's model is the possibility of the central bank to manipulate the interest rate in order to promote growth without sacrificing price stability.

Obviously the assertions of the Post-Keynesians are interesting and given the extensive use of credit-money these days, it is fair to say that they have an important role to play in monetary policy formulation. As a matter of fact, as discussed in Section 2.4, recent empirical studies have shown that the bank credit channel is an important transmission channel in addition to the traditional interest rate and the exchange rate channels.

Having discussed the main views of the different macroeconomic schools on how money could affect real output (and inflation), the next section will cover the monetary transmission channels and their theoretical underpinnings. Obviously the focus now has shifted from: *'Does money have any real effect'* to *'How does money affect real output'*—as implied by the word 'transmission'.

2.4 Monetary transmission mechanisms

As indicated above the focus now is on the process by which a monetary impulse can affect real output[35], i.e. on the transmission channels. This is very important because as Mishkin (1995) puts it, *"Monetary policy is a powerful tool, but one that sometimes has unexpected or unwarranted consequences. To be successful in conducting monetary policy, the monetary authourities must have accurate assessment of the timing and effect of their polices on the economy, thus requiring an understanding of the mechanisms through which monetary policy affects the economy.*" In other words, despite the long history of monetary theory, including the extensive debate just discussed above, there is still uncertainty as to the actual details of the monetary transmission mechanisms. Questions like: Is money endogenous or exogenous, or is monetary aggregate a better policy tool than interest rate, or how does the monetary impulse is transmitted—is it through the exchange rate or through the credit channel, and many more—are still not yet fully resolved or understood. This situation is echoed by Dalziel (1991) who said:

> The survey (i.e. of monetary effects on inflation and unemployment) is all the more important because in fact no clear consensus has emerged about the transmission mechanisms of monetary restraint, to the extent that it is possible to speak of four different frameworks—Monetarist, Neo-Keynesian, New Classical, and Post-Keynesian.

In spite of the uncertainty surrounding monetary transmission mechanisms, there are several transmission channels that have been proposed in order to explain how monetary

[35] In the literature some focus on inflation but in this study the main focus is on real output.

policy affects real output or inflation. According to Mishkin (1995) there are basically four transmission channels found in the literature, viz., interest rate channel, exchange rate channel, 'other asset price effects' channel and the credit channel[36]. However within these four basic models it is possible to use different variables or aggregates in which case there are actually more than four monetary transmission channels. Kuttner and Mosser (2002) also provide a very useful summary of the transmission channels but instead of four they explicitly described six channels. Their channels are basically the same as described in Mishkin (1995) however they separated the credit channel into two, and included one extra channel they call the 'monetarist' channel. This 'monetarist' channel does not depend directly on the interest rate—instead it depends on the relative prices of assets (with interest rate as one of the prices). That is, when monetary policy changes the composition of the assets, the relative prices of these assets will change and this will have real effects. The important assumption here is that the various assets are imperfect substitutes. As Mosser and Kuttner (2002) pointed out, this channel is important in countries where the interest rate is so low that it does not have any more impact on the economy[37].

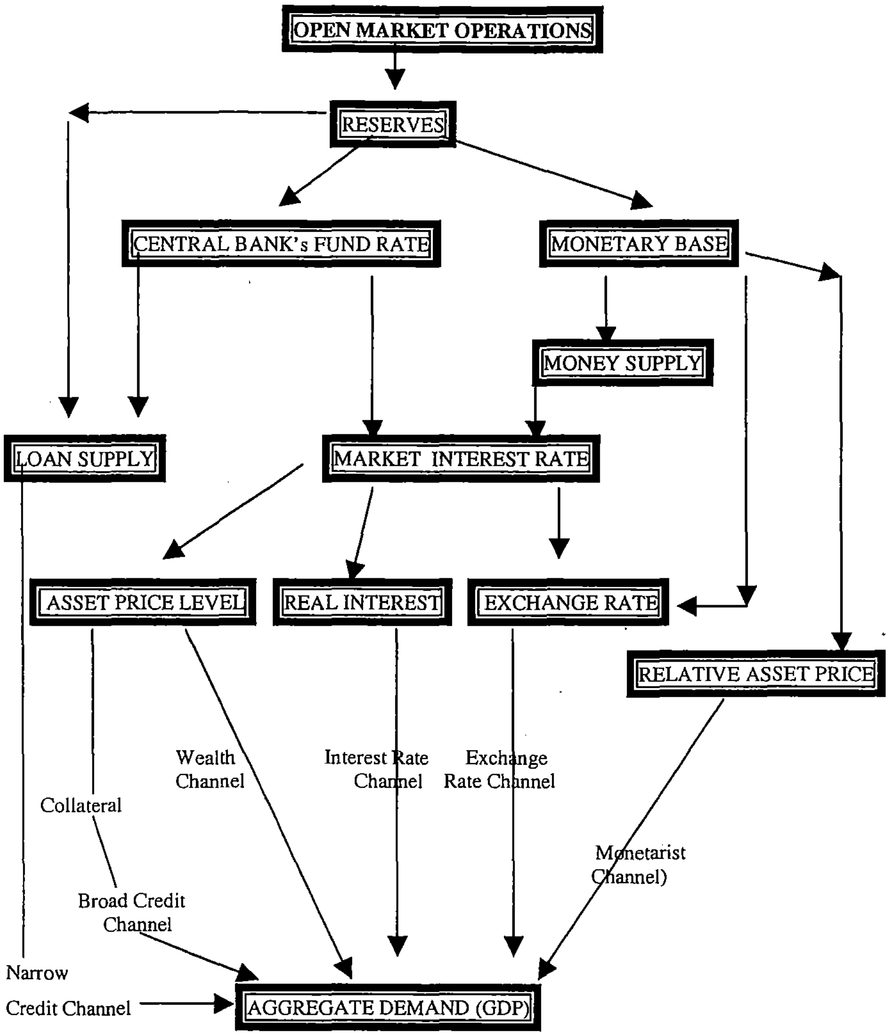
A useful summary of the monetary transmission mechanisms is provided in Fig 2.3. This provides a convenient starting and reference point for the subsequent discussions of the four transmission channels. There may be however slight differences between the variables or flows shown in Fig 2.3 and the subsequent schematic diagrams of the four transmission models but these differences should not affect the substance of the discussions. For instance, investment and exports that are parts of the interest rate channel and the exchange rate channel, respectively, are not shown in Fig 2.3 but this is because both variables are parts of aggregate demand[38]. Also the presence of the real interest rate in Fig 2.3 does not alter the fact that the nominal interest rate set by the monetary authourities affects investment/exchange rate, especially if inflation does not respond immediately. However before discussing the individual transmission channels, it is useful to understand how the

[36] Other interesting papers on the monetary transmission channels include that of Bernanke (1988), Brunner and Meltzer (1988), Meltzer (1995), Norrbin (2000), Rabin and Yeager (1997), among others.

[37] An example of this case is Japan in the late 1990s when it had a serious recession (see, for example, Ueda (2002)).

[38] Aggregate demand is final expenditure on output and in theory they should be the same.

Fig 2.3 Monetary Policy Transmission



Source: Kuttner and Mosser (2002)

central or reserve bank controls the money supply—the starting point of the monetary transmission mechanisms.

In order to control the money supply, the central bank has generally three means to do it: engage in open market operations, selling or purchasing government securities; set the reserve ratio of the commercial banks so as to limit their loans; or set the overnight cash rate which effectively sets other interest rates[39]. The overnight cash rate[40] refers to the rate charged between financial intermediaries (includes commercial banks) on the settlement

[39] See, for example, Friedman (1990).
[40] In the US this is known as the Federal fund's rate.

funds (or reserves) that the intermediaries use to settle their inter-bank claims. How the overnight cash rate is actually set differs from country to country—some countries use the standard open market operations to influence this, such as the United States and Australia[41], while others use the 'official cash rate' system that allows the central bank to set an upper limit for borrowing and a lower limit for depositing. This is called a channel or corridor approach and is used in New Zealand[42].

Now that we have shown and explained how the central bank controls the money supply we will now discuss the different transmission mechanisms starting with the traditional interest rate channel.

2.4.1 Interest rate channel

This channel is really Keynesian in origin, i.e. comes from the IS-LM framework[43]. This model posits that when money supply is increased (i.e. by an expansionary monetary policy), interest rate will decline[44] in line with the standard principle of supply and demand thus lowering the cost of capital[45]. The lower interest rate would attract and encourage businesses (or individuals) to borrow more from the banks and invest in buildings and machinery[46], i.e. this will cause investment to rise which in turn will cause output to rise. The schematic representation of the model is shown below with the vertical arrows indicating expansion ($\uparrow$) and contraction ($\downarrow$) while the 'double' horizontal arrows show the 'causal' direction.

$$M\uparrow \Rightarrow i\downarrow \Rightarrow I\uparrow \Rightarrow Y\uparrow \tag{2.8}$$

where M = money supply; I = investment
i = real interest rate Y = real output

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[41] See, for example, Reserve Bank of Australia (2003, p. 3).
[42] Discussed by Archer et al. (1999).
[43] As pointed out by Cecchetti (1999), *"The traditional view, which is largely the foundation for textbook IS-LM models, is based on the notion that reductions in the quantity of outside money raise real interest rates of return".* Note this traditional channel makes no mention of the loan supply, as noted by Oliner and Rudebusch, 1996).
[44] This is known in the literature as the 'liquidity' effect (see, for instance, Norrbin (2000)). Another way of interpreting this opposite movements is that the interest rate is simply the opportunity cost of holding money (see, for instance, Meltzer (1995)).
[45] The Jorgensonian formula for the neoclassical cost of capital is $(r+d)p_k$ where r is the required real return to lenders, d is the depreciation rate and p_k is the price of new capital (Bernanke and Gertler, 1995).
[46] Mishkin (1995) stresses that investment includes also household investment on dwellings and other fixed assets.

The interpretation of the 'sequential' equation (2.8) goes like this: increase in money causes interest rate to decline; interest rate decline causes investment to increase; and investment increase causes output to rise. This causal ordering will be used when constructing an empirical representation of the model.

Unlike the other demand aggregates such as consumption or exports that generally have immediate impact on output, investment spending has both an instantaneous and a delayed impact on total output, at least in principle. For instance, when there is spending on investment, output naturally goes up immediately if it involves domestic production—say when there is local construction using local inputs. And from standard economic theory we know that investment is meant to generate future income (or value-added) hence the delayed impact.

2.4.2 Exchange rate channel

This channel is quite important for open economies, but in particular for small countries that are well-connected to the rest of the world in terms of trade, finance, tourism, and so forth. This framework, like the interest rate channel, is generally considered as a traditional transmission channel and does not assign an important role to the banking sector. It starts off with the money supply influencing the interest rate. This is then followed by the interest rate affecting the exchange rate which in turn affects the trade activity. For example, when money supply decreases (as when the government tightens up its monetary policy), interest rate will increase as extra demand on the 'smaller' supply of money mounts. Capital inflow may follow given the high interest rate in the country and this will cause the exchange rate to appreciate. As Taylor (1995) points out, *"a high degree of international financial capital mobility currently exists around the world and there is a very simple relationship between short-term interest rate and exchange rate—the interest rate parity relationship.* This currency appreciation will make exports more expensive to foreigners but make imports cheaper to residents. The net result is lower net exports value (as export declines and import rises), and consequently a lower national output. This channel is summarised below:

$$M\downarrow \Rightarrow i\uparrow \Rightarrow E\uparrow \Rightarrow NX\downarrow \Rightarrow Y\downarrow \tag{2.9}$$

where M, i and *Y are* the same as in Equation (2.8); E = exchange rate; NX = net exports

Obstfeld and Rogoff (1995) discuss the costs and the benefits of a 'fixed' exchange rate regime. The two argued that the government that fixes its currency's exchange rate would lose control of the domestic money supply. So obviously the exchange rate model (2.9), with the money supply at the starting point of the transmission, assumes that the government exchange rate is not fixed, i.e. it is flexible.

2.4.3 Other asset price effects channel

As shown in Mishkin's (1995) paper, there are several versions of this transmission channel but the essential feature here is that instead of the interest rate or the exchange rate, prices of other assets (P_e), say price of equities, are included with the Tobin's q measure which equals the market value of the firms divided by the replacement cost (or depreciation). This 'q' measure affects investment that in turn affects output. One representation of this channel is given below.

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow q \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow \tag{2.10}$$

The contraction of the money supply implies less money in the hands of people so they would probably reduce their spending, including their spending in the stock market thus bringing down the price of equities. This reduction in equity prices will mean the market value of the firms will decline relative to their depreciation and the Tobin 'q' measure will therefore decline. This will discourage businesses from spending more on investment knowing that their market value has gone down—consequently output will also decline.

Another version is where instead of the firms, people, as consumers, are considered. That is, following a monetary contraction, and the subsequent drop in equity prices, the wealth of people (particularly investors) would likely go down as well and so they may have to cut back on their consumption expenditure. This decline in consumption will also affect output adversely. This channel is also known as the 'consumption wealth' channel—for obvious reasons of course.

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow wealth \downarrow \Rightarrow consumption \downarrow \Rightarrow Y \downarrow \tag{2.11}$$

Meltzer (1995) also explains this channel but starts off with how open market operations influence the base money and how this subsequently affects interest rates and equity price levels.

2.4.4 Credit channel

This is another important theoretical channel that can be used to explain how monetary effects can reach output. It basically has two versions: one is the bank-lending (or narrow credit) channel and the other is the balance-sheet (or broad credit) channel[47]. The bank lending channel is not affected by the market interest rates because it depends only on the loan capacity of the commercial banks that in turn are affected directly by the reserves and the official cash rate controlled by the central or reserve bank[48]. For instance, a tightening in monetary policy will reduce bank reserves which in turn will cause bank deposits to decline. This decline in deposits will mean the source of loans is reduced and therefore bank loans will decline and consequently investment spending[49]. The schematic representation of this channel is shown below.

$$M \downarrow \Rightarrow \textit{bank deposits} \downarrow \Rightarrow \textit{bank loans} \downarrow \Rightarrow I \downarrow \Rightarrow Y \downarrow \qquad (2.12)$$

The balance-sheet channel, on the other hand, depends on the market interest rates because the balance sheets of both the lenders and the borrowers are affected by the movements in interest rates via the changes in the asset price levels. For instance, when the interest rate increases the prices of the other assets or securities will go down as people shift their wealth portfolio to money asset. This would mean that people or businesses, including lenders, that hold securities would have capital loss on their balance sheet, i.e. their net worth would decline and this would result in reduction of lending because either lenders have now lower collateral for their loans or that borrowers could not be given more credit

[47] Hall (2001) provides a useful description of the two credit channels. In particular he describes how financial stability considerations (i.e. financial position of lenders and borrowers) may affect monetary stability considerations (i.e. how interest rate changes affect spending and inflation).

[48] Two important criteria for this channel to exist is that: banks must not insulate their loan supply after a shock to reserves by simply rearranging their portfolio of other assets and liabilities, and ii), some firms cannot costlessly replace losses of bank credit with other types of finance, but rather must curtail their investment spending (Oliner and Rudebusch, 1996).

[49] This assumes that investment depends on domestic bank loans. In some cases, firms may use their own retained earnings for investment purposes or may rely on external funds, in which case domestic bank loans may not be needed.

because of their lower net worth. This decline in lending will cause investment and output to decline as well. This channel is summarised below but note the inclusion of the terms 'adverse selection' and 'moral hazard'. These are included because they reflect the behaviour of people or businesses when their net worth declines or increases. Naturally a decline in net worth increases adverse selection and moral hazard. However in this study these will not be included in the VAR models because it is difficult to find their empirical representations.

$$M \downarrow \Rightarrow P_e \downarrow \Rightarrow adverse\,selection \uparrow \&\, moral\,hazard \uparrow\, lending \downarrow\, \Rightarrow I \downarrow\, \Rightarrow\, Y \downarrow \quad (2.13)$$

Another slightly different version of the credit model is where private consumption is used instead of investment (see, for example, Bondt (1999)).

While the transmission models described above all start from money supply, the new Keynesian models and most central banks use the interest rate as the monetary policy tool[50]. In view of this it may be necessary in the empirical analysis to run two versions of the models—one with money supply as the starting point of the monetary transmission and the other with the interest rate replacing the money supply variable.

2.5 Summary

What we have looked at in this chapter is a brief evolution of the monetary theory starting off with the nature and definition of money, then moved on to see how the banking system creates money, and finally we examined the different theories of monetary transmission. As noted in the review, the controversy and the ensuing debate between different macroeconomic schools started off because the different theories could not be reconciled with each other and some with empirical evidence. But despite the heated debate and the extensive research there is still no unified theory or consensus on how money actually affects real output. As pointed out by Blanchard (1990), *"Much of the research on economic fluctuations has focused on the effect of money—not because money is a major*

[50] As noted by Meyer (2001): *Monetarism is about money, but money plays no explicit role in today's consensus macro model. It plays virtually no role in the conduct of monetary policy, at least in the United States. The conclusion appeared to be, therefore, that monetarism has had no influence on either macroeconomics or monetary policy.*

source of movements in output but because economic theory does not lead us to expect such effects". In the literature this 'mysterious' process is accordingly dubbed the 'black box'. Bernanke (1988) likens the situation to an aspirin tablet that is effective yet doctors do not completely understand how it works. There are, however, theoretical channels that attempt to describe how monetary impulse gets transmitted to real output, four of which have been explained above. Although the traditional interest rate channel and the credit channel are discussed separately and treated like two distinct channels, some researchers insist that they are complementary to each other in terms of the monetary transmission process. In Brunner and Meltzer (1988) words, *"...the analysis of the transmission process is incomplete without both the money and credit markets and their interactions"*.

This study will investigate this money-output issue starting first with the monetary neutrality proposition and then move on to the monetary transmission mechanisms. The general framework for the empirical analysis is the vector autoregression method first proposed by Sims (1980). For the neutrality test, the Fish and Seater (1993) long run test will be used. The empirical methodology and modelling strategy will be explained in Chapter 5. The next chapter reviews past empirical studies related to neutrality and the monetary transmission mechanisms.

Chapter 3
LITERATURE REVIEW

3.1 Introduction

This chapter will review past empirical studies[1] that have been conducted on monetary neutrality and monetary transmission mechanisms. These two related fields have spawned numerous studies largely because of the long standing problem of reconciling theoretical propositions with empirical data as well as the emerging importance of monetary policy as an essential management tool by governments around the world, in particular after the demise of the orthodox Keynesians prescriptions in the 1970s[2]. Although there is fair amount of empirical work done in these two areas, most have been carried out using the United States (US) data and more recently using European data, i.e. very few studies have been undertaken using New Zealand or Australian data. In view of this the following review will contain a lot of 'international'[3] studies.

3.2 Monetary neutrality studies

On the monetary neutrality empirical studies, the Fish and Seater (1993) paper provides a convenient and important starting point because it formalises a framework for testing the long-run monetary neutrality hypothesis based on the reduced form of the vector autoregression system. This is an important development because before then some prominent economists, such as Lucas, Sargent, McCallum among others, provided examples in which reduced-form econometric methods cannot be used to test long-run neutrality (see, for example, Boschen and Otrök, 1994; Bullard, 1999; and King and Watson, 1997).

Fish and Seater (1993) method relies basically on the integration (or unit root) property of the data[4]. The unit-root property provides the theoretical basis for the variable to depict a 'permanent' change after it has been 'shocked' or disturbed. It is this 'permanent change'

[1] Most of the related developments in monetary theory have been covered in Chapter 2.

[2] In particular the so-called demand management approach of promoting growth or in stabilizing the economy. The acceleration of inflation and the rising unemployment and low economic growth (or stagflation) in the 1970s was attributed to Keynes expansionary policy (see Snowdon et al., 1994, p. 11).

[3] This refers to countries other than New Zealand or Australia.

[4] Most of the past neutrality tests disregard the nonstationary conditions and hence has to be disregarded (Serletis and Koustas, 1988). The unit-root property is discussed in Chapter 4.

feature that allows the test to proceed because it accommodates the concept of having a variable (say money supply) value changed to a different level and remaining there for a long time. As we know this is very difficult to observe in real life, i.e. variables, in particular time series data, rarely make this kind of once-off change and remaining in the new level for a long time. An integrated series therefore gives researchers the opportunity of studying situations or conditions which in real life could be very difficult—if not totally impossible—to obtain.

The Fish and Seater (1993) framework is a bivariate VAR model that includes money supply and output. This is reproduced below simply to facilitate the exposition of the test and for ease of reference.

$$a(L)\Delta^{i} m_t = b(L)\Delta^{j} y_t + u_t \tag{3.1}$$
$$d(L)\Delta^{j} y_t = c(L)\Delta^{i} m_t + w_t \tag{3.2}$$

where m_t = money supply and y_t = real output
$a(L)$, $b(L)$, $c(L)$ and $d(L)$ are lagged polynomials in L
The disturbance vector (u_t, w_t) is assumed to be independently and identically distributed with mean zero and covariance Σ,
the elements of which are σ_{uu}, σ_{uw}, and σ_{ww}.

Constants and trends are suppressed; and if a variable is stationary around a deterministic trend, it is treated as I(0), i.e. stationary. Let $x_t = \Delta^{i} m_t$ and $z_t = \Delta^{j} y_t$ with $i, j = 0$ or 1 (i.e. orders of integration) and $\Delta \equiv (1 - L)$ is the difference operator. The sequence of lagged polynomials in L gives the model a dynamic structure in the sense that the endogenous variables are related to their own past values, i.e. there is a direct link now between contemporaneous and historical data. Generally a_0 and d_0 are normalized to one while b_0 and c_0 are left unrestricted, at least in the 'initial' set up[5]. The number of lags will be determined empirically with the discrimination criteria[6] and LR tests—the intention is to obtain the number of lags that ensures the disturbance term is stationary or a 'white noise' process. Note that the covariance matrix Σ with its nonzero elements imply there is cross-equation correlation in the model. This has implications on the estimation procedure in particular certain restrictions will have to be imposed on some of the model's parameters in

[5] In the 'unrestricted' VAR format these coefficients are not restricted however in the structural VAR, at least one of these will be restricted in order to identify the structural shocks.
[6] Such as the multivariate versions of the Akaike Information Criterion (AIC) or the Schwartz Bayesian Criterion (SBC)—these are described in more detail in Chapter 4.

order to identify the system. In order to estimate their model, Fish and Seater imposed two identifying assumptions: (i) money supply is exogenous (i.e. $b_0 = 0$), and (ii) the covariance $\sigma_{u,w} = 0$, i.e. there is no cross-equation correlation. This latter restriction is based on the assumption that shocks originate from different sources, i.e., independent of each other.

In terms of testing for the long run neutrality (LRN) and long run superneutrality (LRSN) propositions, Fish and Seater employ a concept of a long run derivative (LRD) whose values imply the existence of LRN/LRSN or otherwise. For instance, if output is in nominal terms, then LRD should equal to one (i.e. LRD = 1) for long run neutrality to hold. If output is in real terms, then LRN implies LRD = 0. This long run derivative is formally defined as:

$$\text{LRD}_{z,x} \equiv \lim_{k\to\infty} \frac{\partial z_{t+k}/\partial u_t}{\partial x_{t+k}/\partial u_t} \tag{3.3}$$

$$\text{where } \partial x_{t+k}/\partial u_t \neq 0$$

In order to simplify the exposition Fish and Seater use 'x_t' to denote $\Delta^i m_t$ and 'z_t' to denote $\Delta^j y_t$. It is useful to note that u_t is the money supply disturbance therefore the partial derivatives shown above denote the changes of the variables with respect to money supply shock. In the literature, these partial derivatives are known as impulse responses or simply period multipliers. A series of these constitute the impulse response function and in a bivariate VAR model there are four of these functions. When the impulse responses are added period by period we get the cumulative multipliers and eventually when the series is infinite, as depicted in the LRD formula, we get the long run multipliers. The existence of these long run multipliers however hinges on whether the VAR system meets the stability condition[7]. If this is the case, then convergence is possible and the original VAR model can be fully transformed to the vector moving average form. This is an important form of the VAR because it shows the direct relationship between the endogenous variables and the shocks.

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[7] The stability condition is explained in Chapter 4.

One important aspect that Fish and Seater discussed in their paper and which has been highlighted above, is the need to know the orders of integration of the variables at the early stage of the analysis. This is important because the orders of integration determine how the LRD test statistics are defined. They cited four different cases and these are given below.

Case 1: $i < 1$ (i.e. money supply is not integrated). Here LRD is not defined because money supply has not undergone any 'permanent' change.

Case 2: $i \geq j+1 \geq 1$. Here LRD = 0 because while money supply has undergone a 'permanent' change, output has not, i.e. this is not very informative.

Case 3: $i = j \geq 1$. This case is the most useful in terms of the LRD test because both variables now have undergone the required 'permanent' change, and for neutrality to hold, LRD should equal to zero (if real output is used) and LRD should equal to one (if output is in nominal values).

Case 4: $i = j-1 \geq 1$. This is more complicated because it implies a situation where money supply order of integration is less than output order of integration. For example if money supply is integrated of order one [1] then output is integrated of order two [2], i.e., it is like comparing a change in money level to a change in growth rate of output.

Having defined long-run neutrality in terms of their long-run derivative (LRD) construct, Fish and Seater then analysed previous works and found that most are consistent with long-run neutrality proposition. However, for the US data, they find long-run monetary neutrality fails when they use real output and money but not when they use nominal output. This is rather surprising given that most monetary theories endorse the neutrality hypothesis and because of this, Boschen and Otrok (1994) conducted similar tests but they split the US data into two periods: 1869-1929 and 1940-92. The break coincides with the financial crisis that was experienced by the US in the 1930-33 period. Their findings support the neutrality proposition—even when they use the whole period but with the dummy variable added to account for the financial crisis. Consequently they postulate that the Great Depression of the 1930s caused widespread bank failures and associated financial disruptions that may involve real effects. Haug and Lucas (1997) carry out similar tests using Canadian data and find that indeed neutrality hypothesis holds, in other words, they endorse the Boschen and Otrok findings.

A cross-country study by Bullard and Keating (1995) finds that most of the sixteen countries[8] included in their analysis show evidence in favour of superneutrality. There are a few however that shows some evidence of non-superneutrality, particularly the low inflation countries. The long-run response of output to inflation shock in these countries is positive. Argentina is the only country that shows negative output response. The study uses a bivariate model comprised of annual inflation rate and real output in first-difference—quite similar to Fish and Seater (1993) model but the difference lies in the identification scheme. For instance, whereas Fish and Seater restricted the value of the contemporaneous coefficient b_0 to zero (i.e. money supply is exogenous), Bullard and Keating restricted the long-run multiplier of output shock on inflation to zero[9].

Another important extension to Fish and Seater framework is a study by King and Watson (1997). This study on US data[10] also uses the bivariate VAR as their model but approaches the identification problem in a rather different but interesting manner. They also use slightly different terms. For instance, instead of the long run derivative (LRD) they talk about the long-run elasticity. Their formula is given below.

$$\gamma_{ym} = \frac{\theta_{ym}(1)}{\theta_{mm}(1)} \tag{3.4}$$

where $\theta_{ym}(1) = \Sigma\theta_{ym}$ = long-run multiplier of output with respect to money shock

$\theta_{mm}(1) = \Sigma\theta_{mm}$ = long-run multiplier of money with respect to money shock

It should be quite obvious that the above formula is exactly the same as the Fish and Seater LRD formula (see Equation (3.3)) but now LRD is being replaced by γ_{ym} and the limiting partial derivatives by the ratio of the long-run multipliers. The interesting thing about King and Watson approach however is the use of different identifying assumptions unlike Fish and Seater single restriction approach, i.e. instead of using the single contemporaneous

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[8] Includes Australia and New Zealand.

[9] In terms of the symbols used in King and Watson (1997) method, this restriction is: $\theta_{\pi y}(1) = 0$.

[10] Comprised of 40 years of quarterly observations.

restriction $b_0 = 0$, they use different values for both the contemporaneous coefficients (b_0, and c_0) and the long run derivatives or elasticities (γ_{ym} and γ_{my}). As they put it, "*their approach is more eclectic and potentially more informative*".

As in the standard VAR practice, King and Watson assumed that cov (ε_t^n ε_t^m) = 0. This means that the shocks to money supply are independent of the shocks to the output. This assumption is made in order to reduce the number of structural parameters that needs to be computed, i.e. it is done for identification purposes. However, there is still one more restriction that is required in order to exactly identify the system and as explained above, instead of using a single restriction, they use several restrictions which implies the estimation of a wide range of observationally equivalent models.

King and Watson investigate four different long run neutrality propositions, viz., neutrality of money (money and output), superneutrality of money (money growth and output), the Fisherian theory of inflation and interest rate and the long-run Phillips curve (inflation and unemployment). Their conclusion is that the data contain little evidence against the long-run neutrality of money and suggest a very steep long-run Phillips curve, i.e. there is almost no trade-off between inflation and unemployment[11]. As to the long-run Fisher effect and the superneutrality of money they find the results are not robust to the particular identifying assumption. Over a fairly broad range of identifying restrictions, the data suggest that nominal interest rate do not move one-for-one with permanent shifts in inflation. As to the superneutrality test, the sign and the magnitude of the estimated long-run effect of money growth on the level of output depends critically on the specific identifying restriction employed.

Serletis and Koustas (1998) study on monetary neutrality and superneutrality covers ten countries: Australia, Canada, Denmark, Germany, Italy, Japan, Norway, Sweden, the United Kingdom (UK), and the United States (US). They use the bivariate method of Fish and Seater (1993) however in their identification they adopt the more eclectic approach of King and Watson (1992). They use annual data on money supply and real GDP and their

[11] This may be represented by $\frac{\partial u_t}{\partial \pi_t} \approx 0$, where u_t is unemployment rate and π_t is inflation rate.

results generally support monetary neutrality except the evidence from Italy that violates the superneutrality proposition. The long run of response of output in this case is negative.

Another interesting comparative study between the US and UK is by Coe and Nason (1999) who also use the Fish and Seater bivariate method. For the US they reject the LRN proposition when they employ broad money stock but when they use monetary base, they can no longer reject the proposition. For the UK their test results do not reject the LRN proposition.

One interesting aspect of the Coe and Nason work is the use of an inverse power function to investigate the alternative hypothesis. What they find is that at a reasonable level of Type II error[12], the upper bound they computed yields evidence that long-run non-neutrality of money remains a persistent fact for the US. What this means is that while the LRN is not rejected, the alternative hypothesis (i.e. money is non-neutral) is also not falsified by the data at some reasonable level of Type II error. Based on this they conclude that Fish and Seater test has low power against the alternative hypothesis of monetary non-neutrality.

Whilst most authors cited so far concentrate on long-run neutrality of money, Rapach (1999) focuses his study on the long-run superneutrality of money. His approach is slightly different from the others because he uses a trivariate vector autoregressive model rather than the more common bivariate model. He uses annual data on inflation rate[13], interest rate and real output from fourteen industrialized countries, including Australia and New Zealand. His results indicate that a permanent increase in inflation significantly increases the long-run real output level in a number of countries. He also finds that a permanent increase in the inflation rate lowers the long-run real interest rate[14] in all the fourteen countries and based on these evidences, he concludes that the long-run superneutrality proposition is not supported.

[12] Type II error is the probability of not rejecting a null hypothesis when in fact it is wrong (see, for example, Sheskin, (2000)).

[13] Rapach's use of inflation rate is based on the notion that *"permanent changes in inflation arise solely from equal permanent changes in money growth"*.

[14] This is Fisher's long run relationship between inflation rate and interest rate.

Crosby and Otto (2000) study on the rate of inflation and capital stock provides another interesting and useful dimension of superneutrality. Interestingly they found that *there is no statistically significant long-run effect of interest on the capital stock.* They suggested two possible explanations: their data include both the government and private capital and the positive correlation between the public capital spending and the inflation rate could lead to the insignificant response of capital to inflation rate shock. The second reason is that the different treatments of depreciation and normal interest rate by the taxation authourities could lead to cross-country differences in the relationship between inflation and the capital stock.

A very useful summary of past empirical studies on neutrality and superneutrality is provided in Bullard (1999) paper. This paper surveys earlier works including that of Friedman and Schwartz (1963) study on money and output in the United States as well as that of Sargent (1971) and Lucas (1972) who argued against the reduced form econometric evidence of neutrality. On the evidence of long run neutrality which Lucas (1996) referred to[15], Bullard made a point that the evidence is different to the *'story of a long-run impact of a permanent, unexpected change in the level of money on real output'*. Bullard concludes his paper by stating that while there is not much evidence against long run neutrality, there is mixed evidence for long run superneutrality—as he puts it, *"This is perhaps not too surprising since, as was stressed in the introduction, it is a relatively simple matter to write down neoclassical, market clearing, rational expectations theories in which superneutrality does not hold. In addition, since inflation is generally regarded as a distortionary force in macroeconomic systems, we might reasonably expect real variables to be altered in the face of permanent shocks to money growth and inflation"*.

It is quite clear from the literature cited above that that there is hardly any empirical study on monetary neutrality that have been done particularly in New Zealand and this study therefore has a contribution to make in this respect.

[15] Which consists of the plots of the average rates of monetary growth against average rates of inflation for 110 countries taken over 30 years.

3.3 Monetary transmission studies

As described in Chapter 2 the term 'monetary transmission' is a fairly recent addition to the mainstream monetary literature[16]. In the 'older' literature[17] the term monetary effect or influence or propagation were more common but since the 1990s the term 'monetary transmission' is becoming a fashionable term (see, for instance, Meltzer,. 1995). This may have coincided with the resurgence of monetary policy in the 1970s after fiscal policy was blamed for the double-digit inflation (Mishkin, 1995). It might also have been prompted by other side-effects or unwanted outcomes of monetary policies. For instance, in the mid-1980s Paul Volcker, the chairman of the Federal Reserve Bank of the United States, tightened up monetary policy to slow down inflation but ended up causing a deep recession. It was reported also that the high interest rate caused the rise in exchange rate that eroded away the competitiveness of American industry (Mishkin, 1995). It would be probably these kind of multiple and uncertain effects on the economy of monetary policy actions that prompted serious studies on the so-called transmission mechanisms. As Kuttner and Mosser (2002) report, *"The overall conclusion drawn from the research presented is that monetary policy appears to have less of an impact on real activity than it once had—but the cause of that change remains an open issue"*. Indeed the uncertainty and the complexity of the process had led some researchers to dub it as the 'black box' (see Bernanke and Gertler, 1995; Morsink and Bayoumi, 2001) or 'one of the great mysteries in economics' (see Lown and Morgan, 2002).

In the case of Europe, the interest in monetary transmission is more recent and is most likely driven by the formation of the European Monetary Union in 1999[18]. This is echoed by Mojon and Peersman (2001) introductory sentence: *Understanding the transmission mechanism of monetary policy in the euro area is of primary importance for the implementation of the Eurosystem's monetary policy strategy.* And in the words of Chatelain et al. (2002), *"Since the beginning of monetary union in Europe, a large body of empirical analysis has been devoted to the transmission mechanism of monetary policy"*.

[16] This may be attested by the absence of the term 'monetary transmission' in many standard macroeconomic textbooks like that of Mankiw (1998), Blanchard (1997), among others.

[17] This refers in particular to the earlier works of Patinkin (1987), Sidrauski (1967), Sims (1972), Tobin (1965), among others.

[18] As noted by Norrbin (2000), *"Most studies of the transmission effects of monetary policy have been done for the U.S., but more recently studies of other countries have been performed to verify the robustness of the results for the U.S."*

Some empirical studies investigate monetary transmission across different countries (such that of Angeloni et al., 2002; Britton and Whitley, 1997; Cecchetti, 1999; Chatelain et al. 2002; Bondt, 1999; McCoy and McMahon, 2000; Peersman and Smets, 2001; among others) while others focus on individual country's data (see, for example, Aron and Muellbauer, 2002; Berument, 2001; Bredin and O'Reilly, 2001; Erden, 2002; Holtemoller, 2002; Hubrich and Vlaar, 2000; Lown and Morgan, 2002; Ludvigson et al., 2002; and Lutkepohl and Wolters, 2001). There are also some studies that examine and compare different transmission channels, such as Angeloni et al. (2002), Bean et al. (2002), Bernanke and Gertler (1995), Deutsche Bundesbank (2002), Mauskopf (1990), Rabin and Yeager (1997), among others. And while some studies use aggregate data, other studies use industry or firm-level data (such as Chatelain et al., 2002; Kashyap and Stein, 2000; and Peersman and Smets, 2002).

Obviously the list of empirical works on monetary transmission has grown quite substantially in recent years. The scope and focus of the studies are also quite wide-ranging and so to make some reasonable flow in the following review it is necessary to adopt some systematic approach to the review process. In view of the main objective of this thesis, which is to evaluate alternative monetary transmission mechanisms, it is logical to split the empirical literature into the four main transmission channels: interest rate channel, the exchange rate channel, the other asset price effects channel and the credit channel. In doing this it should be easier to see and appreciate the differences or similarities among the different transmission mechanisms as well as getting useful insight as to what methodological approaches and techniques were used to evaluate each transmission mechanism in the past.

3.3.1 Interest rate channel

Although the interest rate channel is often referred to as the traditional transmission channel, there seems to be more focus and more empirical works carried out on the credit channel—at least in recent years. As pointed out by Oliner and Rudebusch (1996), *"In recent theoretical and empirical research, interest has been rekindled in a credit channel for the transmission of monetary shocks to real output"*. Perhaps one reason for this is the difficulty (as noted by Bernanke and Gertler, 1995) in explaining the magnitude, timing and composition of the economy's response to monetary policy shocks solely in terms of conventional interest rate (neo-classical cost of capital) effects—as they put it: *the mechanisms collectively known as the credit channel help fill in the gaps in the traditional story.* Chirinko (1993) also noted that only a few authors have applied vector autoregression approach to investment spending, a principal component of the interest rate channel. Some of the VAR studies that look at the interest rate channel include Angeloni et al. (2002), Chatelain et al. (2002), McCarthy and Peach (2002), Mojon et al. (2001), Peersman and Smets (2001), among others.

McCarthy and Peach (2002) use US data on real GDP, the GDP deflator, commodity prices, residential investment in single-unit structures, single-family home prices relative to the GDP deflator, federal funds rate and mortgage rates to study the impact of monetary policy on investment. To identify the shocks they use the Cholesky decomposition with the variables ordered as listed above[19]. They find that following an increase in the funds rate, investment declines by 3 per cent after two quarters while output declines by 0.3 per cent. However for more recent data (i.e. after 1986) the impact is much delayed and they cite the persistent of the funds rate increase in this period and the positive mortgage response later in the period as possible reasons for such delay. But according to Bernanke and Gertler (1995) the lagged response of inventories and non-residential investment can be explained by the variation in the external finance premium. For instance, when monetary policy tightens up, the balance-sheet of firms deteriorates as interest rate increases and cash flow declines. This will cause the premium for external finance to increase which in turn will cause 'financial pressure' to build up hence the delayed but sharp response of investment following monetary policy tightening.

Peersman and Smets (2001) using data on Europe find that the response of investment to monetary policy shock is three times as large as output response to the same shock. They also find that investment response is higher than consumption response. Another interesting study by Mojon et al. (2001) on Germany, France, Italy and Spain, finds that the user cost

[19] By putting the interest rate last means that the policy tool is the most endogenous of the variables, i.e. it is affected contemporaneously by other variables but its effect on other variables occurs after a lag. This ordering would be the exact opposite of the transmission models that Mishkin (1995) discussed, i.e. this ordering will be different to the ordering used in this study.

of capital, which is affected by the interest rate, has a statistically and an economically significant effect on investment. The study uses firm level data from 17 industries in each country and the long run elasticities were estimated using the error correction form of the autoregressive-distributed equation with investment as the dependent variable and the interest rate and the user cost of capital as the explanatory variables. Their hypothesis is: *Smaller firms are subject to greater informational problems and are thus affected more strongly by a monetary policy tightening*.

Angeloni et al. (2002) study, like Bernanke and Gertler (1995), focuses on the question: *Can the classic interest rate channel alone, without capital market imperfections, explain the stylised facts of monetary transmission?* They draw on the empirical results of previous studies[20] and their conclusion is that in some countries (e.g. Belgium, Germany, Finland, France, Italy, and Spain) the interest rate transmission channel completely characterizes the monetary transmission process. In countries where the interest rate channel is not dominant they find direct evidence supporting the presence of the bank-lending channel (or other financial transmission channel). The studies are based on the VAR and the structural models. The authors also pointed out one interesting difference with the US evidence: whereas investment in Europe is a significant driving force behind output, in the US, consumption is more significant.

One interesting aspect of Angeloni et al. (2002) study is their approach in trying to assess the dominance of the interest rate channel. Their testing strategy is sequential and they considered three parameters: the elasticity of output with respect to monetary policy; the elasticity of investment with respect to the same shock; and finally the elasticity of investment with respect to the interest rate. This last parameter is calculated as to exclude the other effects of monetary policy. And the condition for the interest rate channel to be significant is for the investment movement to have a large impact on output movement. Another condition is for the interest rate elasticity to account largely for the overall elasticity of investment with respect to monetary policy. If the outcome does not support the interest rate channel, then they look for evidence of financial factors (such as cash flows).

[20] Such as Ehrman et al. (2001), Mojon and Peersman (2001), Peersman and Smets (2001), among others.

Chatelain et al. (2002) study on the monetary transmission channels on firm investment for Germany, France, Italy and Spain find evidence to support the interest rate channel. They use micro datasets for each country containing over 215,000 observations from 1985 to 1999. They use an auto-regressive distributed lag model based on the neo-classical investment relationship with investment as the dependent variable and the user cost, sales and the cash flow as the explanatory variables.

3.3.2 Credit channel

As indicated in the previous section, the credit channel is further split into two channels: one is the balance-sheet (or broad credit channel) and the other is the bank-lending (or narrow credit channel). Some of the empirical studies on the balance-sheet approach include, Bondt (1999), Morsink and Bayoumi (2001), Oliner and Rudebusch (1996) among others. As to the bank-lending channel, some studies include that of Cecchetti (1999), Estrella (1999), Kasyap and Stein (2000), and Heuvel (2002). Other studies estimate and examine both credit channels, such that of Bernanke and Gertler (1995), Chrystal and Mizen (2002), Holtemoller (2002), and Lown and Morgan (2002). Fackler and Rogers (1993) study is slightly different with the others because he incorporates the exchange rate in his credit model. As they put it, *"We are unaware of any credit-view models which explicitly analyse the role of the exchange rate, although such a role is often hypothesised..."*.

Bernanke and Gertler (1995) study is one of the earlier works on transmission channels and is often cited by more recent empirical studies[21]. They use US data to observe what happens after monetary policy tightening. The stylised facts they observe include: sustained declines in output and price level; final demand falls relatively fast after monetary shock whereas stock of inventories initially rises but ultimately declines; the earliest and sharpest declines in final demand occur in the residential investment followed by consumer spending; fixed business investment eventually declines but after residential investment and consumer spending. As to the actual pattern of output response, it starts to decline in the 1st quarter after the monetary shock and bottoms out after two years. In their estimation, the demand

[21] Such as Azali and Mathews (1999), Holtemoller (2002), Meltzer (1999), Warner and Georges (2001), among others.

components of output, such as business investment or consumer spending, are added one at a time to the VAR model, i.e. they are not estimated in one go. However there are three empirical puzzles that they observed: monetary policy shocks affect the real economy significantly (unlike previous empirical study findings); the timing of the interest rate movements seems odd in the sense that it quickly returns to its trend after eight to nine months while the other variables are just starting to respond; the third puzzle is that out of the demand spending components, residential investment seems to be the most responsive variable to monetary policy shock—contrary to what is expected which is that residential investment should react not to short term interest rates but to long term rates.

In view of the puzzles (which they claim as the shortcomings of the conventional analysis of the monetary transmission) Bernanke and Gertler went on to investigate the balance-sheet and the bank-lending channels. In particular they concentrated on the 'external finance premium' which is essentially a wedge or cost between the lender and the borrower. This cost depends on the net worth of the borrower, i.e. if the borrower has lower net worth then the external finance premium will be high, and vice versa. An increased net worth in the balance sheet would therefore result in lower external finance premium that in turn may encourage the firm (or individual) to borrow more for investment purposes. This is the balance-sheet explanation. In terms of the bank-lending channel, the external finance premium is affected by the monetary policy because the reserves is reduced after monetary policy tightening which in turn affects the ability of the banks to extend more loans to borrowers. The key assumption here is that the banks cannot easily replace lost deposits with other sources of fund, such as certificates of deposit or new equity issues. Bernanke and Gertler argued that the two credit channels and the external finance premium are able to explain the puzzles noted. However they do note great difficulty in carrying out an empirical test that would conclusively separate the bank-lending channel from the balance-sheet channel.

Oliner and Rudebusch (1996) study finds support for the broad credit or balance-sheet channel. They use a single equation model with fixed investment as the dependent variable and the 'sales' and 'cash flow' as the explanatory variables. Lags of the explanatory variables as well as the dependent variables are included to reflect the dynamics involved as well as to reduce the problems of simultaneity. The equation is given below[22]:

$$KF_t = a_i KF_{t-i} + \alpha_j \Delta S_{t-j} + \gamma_j \Delta COC_{t-j} + \beta_1 CF_{t-1} + u_t \qquad (3.5)$$

where KF = gross investment
ΔS = change in net sales
ΔCOC = change in cost of capital
CF = cash-flow
$i = 1,\ldots,4$ *and* $j = 0, 1, \ldots, 8$.
$u_t \sim N(0,\sigma^2)$

Oliner and Rudebusch approach is interesting in that they use three different definitions of 'monetary tightening' in the US. The first definition follows that of Romer and Romer (1989, 1994)[23] narrative approach; the second is based on large increases in the nominal federal funds rate and the third corresponds to the dates when the term spread (defined as the funds rate minus the rate on the 10-year Treasury note) is at least 65 basis points. These dates are included in the regression equation as dummy variables, i.e. four quarters following the date of monetary tightening are assigned unity, and the rest zero. After monetary tightening the coefficients of the dummy variables for the smaller firms are found to be significant suggesting the importance of cash flow to investment spending. However when monetary easing is modelled the coefficients are no longer significant. According to Oliner and Rudebusch this provides evidence of the broad credit channel.

An interesting study by Morsink and Bayoumi (2001) using Japanese data shows that banks do play a crucial part in transmitting monetary shocks to economic activity. This may not be too surprising given that they also found evidence that corporations and households have not been able to substitute borrowing from other sources for a shortfall in bank borrowing, i.e. corporations and households in Japan strongly depend on the banking sector. They also found that business investment is especially sensitive to monetary shocks. Their modelling strategy was to start off with a 'basic' VAR and then progressively adding on other variables like bank loans, securities, other components of investment, and noting the changes in the response functions and the variance decompositions. Their 'basic' VAR

[22] Although the symbols and the subscripts here are slightly different to that in the 'original' equation in the paper, the two equations are exactly the same.
[23] As cited in Oliner and Rudebusch (1996).

model is comprised of real private demand, prices (CPI), interest rate (overnight call rate[24]) and broad money. They include also a constant term, a time trend and two dummy variables to account for the introduction of the consumption tax in April 1989 and its increase in April 1997. They use quarterly seasonally data from 1980:1 to 1998:3 and for identification purposes, they use the Cholesky decomposition with the ordering of the variables as listed above. The implication in this ordering is that money aggregate is the most endogenous while private demand is the most exogenous. The assumption behind this ordering is that real variables take time to react to changes in financial variables. However they noted that reversing the ordering of the variables gave similar results, i.e. their results seem to be robust to the ordering of the variables.

The cross-country study by Bondt (1999) found that there is an accelerator effect of the external finance premium on consumption for Germany, Italy and the Netherlands but not for France, United Kingdom and Belgium. For the external finance premium, Bondt uses different measures for different countries however one common measure is the difference between the mortgage rate and the savings deposits rate. He uses the mortgage rate because he considered the rate to be related to the net worth of consumers. His model is a consumption equation with real interest rate, real income, and external finance premium as the main explanatory variables. The lags are also added because of the dynamics involved. The equation is given below:

$$\Delta c_t = u + \theta\, r_{t-1} + (\lambda_1 + \lambda_2)\Delta y_t + \alpha_1' \;\; \Delta EFP_{t-1} + \alpha_2' \; \Delta EFP_{t-1} \bullet bc_{t-1} + \varepsilon_t \tag{3.6}$$

where c_t = consumption
r_{t-1} = real interest rate
y_t = real disposal income
EFP_{t-1} = external finance premium
bc_{t-1} = business cycle
λ_1 = proportion of consumers consuming a constant fraction of income
λ_2 = proportion of consumers consuming constant fraction of both income and the available supply external finance

$u = (1-\lambda_1-\lambda_2)u^* + \lambda_2\alpha_0$, $\theta = (1-\lambda_1-\lambda_2)\sigma$, $\alpha_1' = \lambda_2\alpha_1$, $\alpha_2' = \lambda_2\alpha_2$

ε_t = error term that is orthogonal to all variables at time t-1

From Equation 3.6 he derives three variants of the consumption equation. His first equation is for liquidity-constrained consumers that he got by setting $\lambda_2 = 0$. For the second

[24] Same as the federal funds rate (in the case of the U.S.) or the official cash rate (in the case of New Zealand).

category he assumes no financial accelerator effect, i.e. he sets $\alpha_2 = 0$. And for the last consumption equation he did not put any parameter restrictions.

Bondt consumption equation is the result of a utility maximization exercise. His utility or objective function is given below:

$$V_0 = E_0 \Sigma_t (1+p)^{-1} U(C_t), \qquad t = 0,1,.......T \tag{3.7}$$

And his wealth constraint function:

$$A_{t+1} = (1+r_t)(A_t + Y_t^{\alpha} - C_t), \qquad t = 0,1,........T \tag{3.8}$$

where $U(*)$ = utility, strict concavity and double differential; C_t = real per capita consumption; p = individual rate of time preference; E_t = expectation operator conditional on information at time t; A_t = net real asset; Y_t^{α} = real labour income; r_t = real interest rate

After maximizing (3.7) subject to the wealth constraint given in (3.8), which involves solving first order conditions for the utility equation, and after appropriate substitutions, the main consumption equation (3.6) is obtained.

On the bank-lending channel, Kashyap and Stein (2000) study on US banks provides evidence that the impact of monetary policy on lending is stronger for banks with less liquid balance sheets—these banks are generally smaller, i.e. in the bottom 95 per cent of the size distribution. This implies that open-market operations can actually shift the loan supply schedule, a situation that would mean a failure of Modigliani-Miller proposition[25]. The study stresses the problem of identification, in particular in identifying whether or not the loan supply schedule actually shifted. This problem arises because there are other possible explanations for the observed change in bank lending—i.e., it could be that the demand for loans actually declined following a decline in activity as a result of monetary tightening, or it could be that the monetary tightening weakens the creditworthiness of small firms thus reducing their ability to obtain loans from banks and other lenders (i.e. balance-sheet approach). To resolve the issue Kashyap and Stein focuses on individual bank behaviour and their approach rests on the assumption that banks cannot easily use

[25] The Modigliani-Miller proposition is that banks are indifferent at the margin because they can easily substitute loans with other securities, hence shocks to bank loans will not affect the bank lending channel (this is well illustrated in Romer and Romer, 1990).

other securities for loan purposes when the reserve bank reduces their insured deposits by tightening its monetary stance. If the assumption is true, they reckon the effect of monetary policy on lending should be more pronounced for some banks than others. The criteria they use is the liquidity status[26] of the banks and their hypothesis is that smaller banks, because of their inability to raise uninsured finance, would be affected more by monetary policy tightening than larger banks.

Kashyap and Stein (2000) did raise a very relevant and important question on the choice of variable or construct that could be used for monetary policy stance. They discussed three possible candidates: the Boschen-Mills (1995) index (based on readings of FOMC documents); the federal funds rate; and the Bernanke-Mihov indicator. They decided to use the last construct because even if the contraction in policy is partially anticipated by banks, it should still have the cross-sectional effects that they hypothesized. Their model involves a two-step regression. The regression equations are given below.

$$\Delta \log(L_{it}) = \sum_{j=1}^{4} \alpha_{ij} \Delta \log(L_{it-1}) + \beta_t B_{it-1} + \sum_{k=1}^{12} \Psi_{kt} FRB_{ik} + \varepsilon_{it} \tag{3.9}$$

where L_{it} = bank loans
B_{it-1} = bank liquidity (securities/assets)
FRB_{ik} = Federal Reserve-district dummy variable (i.e. geographic control)

$$\beta_t = \eta + \sum_{j=0}^{4} \phi_j \Delta M_{t-j} + \delta TIME_t + u_t \tag{3.10}$$

where M_{t-j} = monetary policy measure
$TIME_t$ = time trend

$$\beta_t = \eta + \sum_{j=0}^{4} \phi_j \Delta M_{t-j} + \sum_{j=0}^{4} \gamma_j \Delta GDP_{t-j} + \delta TIME_t + u_t \tag{3.11}$$

where GDP = real GDP growth

The key parameter in the above equations is β_t as it reflects the 'intensity' of liquidity constraints in a given size class at time t. Equations (3.10) and (3.11) are just two variants of the pure time series regression of β_t on monetary stance. To test their hypothesis the important term is the sum of the coefficients of the monetary policy measure, i.e. $\sum_{j=0}^{4} \phi_j$ in

[26] Defined as ratio of securities to assets.

(3.10) or (3.11). For robustness check on their results, they ran a one-step regression that essentially combines (3.9) and (3.10), or with (3.11). Another robust test they did was to replace β_t with the residuals obtained by regressing β_t on the ratio of commercial and industrial loans to total loans; the ratio of real estate loans to total loans; the ratio of individual loans to total loans; and a time trend.

Cecchetti (1999) study is quite interesting in that it brings in the legal structure dimension to the monetary transmission subject. He argues that the differences in the financial structure across the countries of Europe are a consequence of their dissimilar legal structures. His hypothesis is: Countries with poor shareholder and creditor protections and poor law enforcement will have less developed financial systems and greater sensitivity of output and inflation to interest rate changes. His study concentrates on the 'lending' channel across countries, and as he puts it: *Overall, this analysis allows me to evaluate the likely strength of the lending channel across countries.* His data include the size and concentration of the banking system in each country; measures of the banking system health; the importance of bank financing; and the size of the firms. Cecchetti also constructed an index of the probable strength of the monetary transmission mechanism based on the balance sheets of banks and on the development of equity and debt markets in the various European countries. His main finding is that the impact of interest rates on output and prices differ across the countries as a result of differences in the size, concentration, and health of the banking system as well as in the availability of alternatives to bank financing. More important though, he finds that the differences are due to the differences in the countries legal structures.

The importance of bank capital (or equity) to the bank lending channel is also investigated by Heuvel (2002). His finding is that: *Monetary policy affects the supply of bank loans through its effects on bank equity. This dynamic effect—the bank capital channel—amplifies the standard interest rate channel of monetary policy.*

Fackler and Rogers (1993) study finds evidence that the credit transmission channel, incorporating international factors, is an important transmission channel. More specifically, movements in the exchange rate are found to have significant effects on domestic credit, and that changes in credit are important in explaining movements in output, prices and interest rates. They use a seven-variable VAR model with the following variables: government expenditure; GNP deflator; trade-weighted value of the US dollar; money supply (M2); total domestic debt; real GNP; and the federal funds rate. All the variables are tested for unit root and cointegration[27]. They did not, however, find any evidence of cointegration so they just used the standard VAR with variables in first difference. They also carried out a multi-variate Chow test on the reduced-form VAR for stability. A breakpoint 1980:4 was tested using the likelihood ratio test. Their finding is that there was no significant structural break in the period so they used the entire period 1973:2 to 1989:1. To obtain the impulse response functions and the variance decompositions, they used the structural VAR approach calling the residuals the 'structural' or 'fundamental' shocks.

An interesting study by Warner and Georges (2001) focuses on the credit view of the monetary transmission mechanism using stock market returns. They identify the Fed policy shocks using newspaper accounts and track daily stock prices immediately following the shocks. Their hypothesis is: If the credit channel is important, then the firms that are dependent on bank credit and internal funds should receive a relatively greater benefit from a Fed easing than firms with access to non-bank credit at favourable terms. They identified ten policy shocks during the 1991-94 period but find little evidence supportive of an operative credit channel.

3.3.3 Other asset price effects (or consumption wealth) channel

There seems not to be many empirical studies done on this particular channel. This may be due to the absence of the interest rate and the banking sector in the model. Besides, statistics on household wealth are rarely compiled. That is, in many countries, time series statistics on household or private consumption are difficult to compile and typically are estimated as residuals, i.e. obtained indirectly from other statistical aggregates[28]. In spite of this, the wealth channel has deep roots in the literature on monetary policy and economic stabilization, reaching back to Pigou, Haberler, Keynes, Modigliani and Patinkin (see

[27] For the cointegration test they used the Durbin-Watson (CRDW) approach.

[28] Of all the national accounts macro aggregates, the derivation of household consumption is the most subjective in the sense that it involves regular and ongoing household surveys otherwise it is simply estimated as a residue.

Ludvigson et al., 2002). Meltzer (1999) also noted the importance of this channel when he discussed the shortcomings of the interest rate channel as the sole transmission channel.

The recent study by Ludvigson et al. (2002) finds scant evidence of the importance of the wealth channel for monetary policy. They use two econometric approaches in evaluating the impact of the wealth channel. First they use a large-scale econometric model and in the second they use a small structural VAR. In the former they find there is some role for the wealth channel but in the VAR approach they find little or no sign at all. In the VAR approach they first estimate a 'baseline' model with the following variables: consumption (c), labour income (y), asset wealth (household net worth compiled from Flow of Funds data) (a), federal funds rate (*ff*), and inflation rate (π). But instead of using the Cholesky decomposition to identify the structural shocks, they use a more 'structural' approach in the sense that they base their restrictions on several theoretical assumptions. First they assume that the federal funds rate responds contemporaneously to consumption and to labour income, but changes in these two variables affect the funds rate with a one-period lag, so they set $\beta_{35} = 0$. The second assumption is that asset wealth is not contemporaneously influenced by consumption, and so they restrict $\beta_{35} = 0$. The last assumption is where the funds rate has contemporaneous impact on asset but asset does not have the contemporaneous impact on the funds rate (i.e. $\beta_{54} = 0$). The resulting endogenous coefficient matrix is given below:

Baseline VAR model

$$B_0 = \begin{array}{c} \\ \pi \\ y \\ c \\ a \\ ff \end{array} \begin{array}{c} \begin{array}{ccccc} \pi & y & c & a & ff \end{array} \\ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 \\ \beta_{3} & \beta_{32} & 1 & \beta_{34} & 0 \\ \beta_{41} & \beta_{42} & 0 & 1 & \beta_{45} \\ \beta_{51} & \beta_{52} & \beta_{53} & 0 & 1 \end{bmatrix} \end{array} \tag{3.12}$$

Note that this is a just-identified model given there are ten restrictions imposed[29].

[29] This is consistent with the formula $(n^2 - n)/2$ --see, for example, Enders (1995).

In order to gauge the effect of the wealth channel, Ludvigson et al. did a counterfactual simulation with the wealth effect 'shut off'. To carry out the counterfactual experiment the contemporaneous response of consumption to asset wealth shock (β_{34}) is restricted to zero. The same restriction is done also on the lagged coefficient matrices but as the authors noted, in practice, shutting off the lagged effect of asset wealth on consumption has little impacts on the results. To illustrate this procedure the contemporaneous relations matrix *(B_0)* is shown below with the appropriate restrictions.

'Shutting-off' wealth channel model

$$B_0 = \begin{array}{cc} & \begin{array}{ccccc} \pi & y & c & a & ff \end{array} \\ \begin{array}{c} \pi \\ y \\ c \\ a \\ ff \end{array} & \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ \beta_{21} & 1 & 0 & 0 & 0 \\ \beta_{3} & \beta_{32} & 1 & 0 & 0 \\ \beta_{41} & \beta_{42} & 0 & 1 & \beta_{45} \\ \beta_{51} & \beta_{52} & \beta_{53} & 0 & 1 \end{bmatrix} \end{array} \qquad (3.13)$$

By comparing the responses emanating from the two VAR models, they managed to measure the contribution of the wealth-channel to the transmission of monetary policy.

3.3.4 Exchange rate channel

Although the exchange rate has been a central feature of open-economies, and continues to be a an issue of great importance to economic planners, including monetary policy makers, not many empirical studies have been conducted that trace the monetary policy transmission from its source, say from changes in money supply right through to output via the interest rate, the exchange rate and exports. It seems most studies undertaken so far are either partial or incomplete as far as the full exchange rate transmission channel is concerned. For instance, some empirical studies just examine how monetary policy affects exchange rate (Ahn, 1994; Dalziel, 2002; Faust et al., 2002; Kumah, 1996; among others) while others focus more on the 'direct' impact of exchange rate on output or inflation (Fackler and Rogers, 1993; Kamin and Klau, 1997; Odusola and Akinlo, 2001; Smets and Wouters, 1999; among others). In fact there is a vast empirical literature that considers exchange rate in its various forms and roles however for the purpose of this study only those that are more closely related to the monetary transmission concept will be reviewed here.

Smets and Wouters (1999) use the VAR approach to study the role of exchange rate in the monetary transmission in Germany. Their VAR is comprised of real GDP, consumer price index, day-to-day rate, the real effective DM exchange rate, real net exports, import prices, export prices, the US real GDP, and the US federal funds rate. They use a recursive identification scheme with the variables ordered as listed (except the US variables which are put in front in order not to be affected contemporaneously by the local variables). For the monetary policy stance[30], they use a weighted average of the interest rate and the exchange rate, i.e. their policy shock is defined as:

$$\varepsilon_t^p = (1-\omega)u_t^i + \omega\ u_t^s \tag{3.14}$$

where ε_t^p = is the weighted policy shock
ω = is the weight employed by the central bank
u_t^i = is the interest rate shock
u_t^s = is the exchange rate shock

However unlike Canada and New Zealand[31] where the weight ω is known (because they use the monetary conditions indices (MCI)), in Germany there is no MCI therefore they estimated the weight by running a regression of interest rate innovation on exchange rate innovation. The estimated value of the weight is over 0.2 and so they decided to use 0.25. In fact by changing the value of the weight the authors are able to examine different impulse response scenarios. Their main finding is that a tightening in monetary policy causes a strong and prolonged exchange rate appreciation. This in turn causes the prices of imported goods to decline that in turn cause the consumer price index to decrease. They also find the decline in import prices is more significant than the increase in export prices so overall the terms of trade improves after monetary tightening.

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[30] Deciding on what is the structural monetary policy shock is often a contentious issue, especially in the case of an open-economy where there are contemporaneous relationships between interest rates and exchange rate (see, for example, Christiano et al., 1998; Faust and Rogers, 2002; Faust et al., 2002).

[31] Review of the MCI application in New Zealand can be seen in Engelbrecht and Loomes (2002), Guender and Matheson (2002), among others.

Kamin and Klau (1997) using an error correction model find no evidence that devaluations are contractionary in the long run. They use a panel data of 27 countries from Latin America, Asia and from the industrial countries. On the other hand, Odusola and Akinlo (2001), using Nigerian data, produce mixed results. In the medium to long term, exchange rate depreciation causes output to expand but in the short term, output contracts. They use a VAR model with six variables: nominal exchange rate; interest rate; parallel exchange rate (i.e. black-market exchange rate); output; price; money supply. Their identification approach is non-recursive, i.e. structural—as they put it, *"We specify the identification restrictions adopted to best capture the joint behaviour of the market fundamentals in the Nigerian economy"*. The use of the parallel exchange rate is fairly unique but they consider it relevant because the 'official' exchange rate is 'administratively managed', i.e. not left to free market forces.

Having reviewed some of the monetary transmission studies undertaken in the rest of the world, we will now look at some of the empirical studies undertaken in New Zealand and Australia.

3.4 Studies in New Zealand and in Australia

It should be obvious that virtually all the studies cited above refer to studies in the United States or in Europe. This is because not many studies have been undertaken in New Zealand or Australia on monetary transmission—apart from the few that will be cited below. In view of this, the following review may include studies that are not strictly transmission channel studies but are nevertheless considered important and relevant to the conduct of monetary policies. We will look first at studies done for New Zealand.

Guender (1998) study on the bank-lending channel of monetary policy is one the few transmission studies undertaken in New Zealand. He finds no evidence for the bank-lending channel[32], and as he puts it: *Overall, our empirical findings show that the systematic relationship between economic activity and various quantity—or price based measures of credit conditions observed in other countries, particularly the United States, is absent from New Zealand data.* He uses a single regression and bivariate Granger-causal models to

[32] Meltzer (1995) also noted the lack of empirical evidence for the bank lending channel—as he puts it: *However, the academic evidence for the importance of a bank lending channel is relatively weak.*

investigate the relationships. These include the relationship between the finance variable mix (that he defined as the ratio of bank loans to the sum of commercial bills and bank loans) and economic activity; the movements between the interest rate spread and the real economy; and the relationships between these variables and the various indications of the monetary policy. For the monetary policy instrument he uses the discount rate, saying, *"We choose the discount rate primarily for its importance as a signalling device before the reforms of the mid-1980s but also because it is the only policy instrument for which data spanning the 1975-1994 period exists"*.

Another interesting study is that of Taylor (1997) who examined the causal relationship between output and monetary policy variables. He uses the vector error correction model with the following variables: money supply, interest rate, price, exchange rate and output. His main finding, based on the Granger-causality test, is that real output Granger-causes money supply and other three variables, i.e. money supply and the other three variables seem to be more endogenous than exogenous—as in the real business cycle theory. He also finds that money expansion is likely to be dissipated through higher prices and exchange rates.

Conway (1998) studied the macroeconomic variability in New Zealand using a structural VAR approach. His finding is that a considerable share of variability in New Zealand macroeconomy is due to external or foreign shocks—especially in the long run. His variables include output (real GDP), employment (total employment hours), real interest rate, terms of trade, and two foreign variables—US real GDP and US real interest rate. He uses two methods to remove the stochastic trend in his data—by taking the first-difference, which is the more common method, and by using the Hodrick Prescott (HP) filter. He also uses two periods—one starting from 1977:2 to 1996:1 and the other starting from 1985:2 to 1996:1. This latter period coincides with the time the control over interest rate and the exchange rate was removed. Because the shocks are defined as one standard deviation of the values of the variables Conway refers to the magnitude of the responses as some proportion of the standard deviation unit.

A more recent transmission study using New Zealand data is that of Wongsaart (2002) who uses the structural VAR approach to analyse monetary policy impact on the macroeconomy. Using Kim and Roubini (1999) structural VAR format as a basis, Wongsaart then went on to include one cointegration equation of money demand after finding evidence of one cointegration relationship among the variables. In fact, he estimated two models—one that follows basically Kim and Roubini (1999) and Brischetto and Voss (1999) approach, and the other (of his own design) that uses the variables in first-difference with the money demand cointegration relationship, i.e. a vector error correction model (VEC). He uses output (nominal GDP), domestic price level (consumer price index), narrow money aggregate, interest rate (short-term interest rate), exchange rate (US$/NZ$), US interest rate, and the domestic oil price index. In his conclusion Wongsaart claimed that his 'modified' model is more satisfactory in the sense that *"its results are free of the empirical anomalies often found in the previous studies"*.

Two interesting and related papers by Buckle et al. (2002) and Buckle et al. (2003) discuss an open economy structural VAR model for New Zealand that follow the techniques introduced by Cushman and Zha (1997) and Dungey and Pagan (2000)[33]. Their model includes international variables and an expanded list of domestic variables including a climate variable to capture the impact of climatic conditions on the business cycle[34]—a total of fourteen variables altogether. Their data enter the VAR model as deviations from the long run trend obtained from the Hodrick-Prescott filter. They also use a forward-looking Taylor rule to identify the monetary policy[35]. On the estimation issue they use the 'seemingly unrelated regression' or SUR rather than the ordinary least squares (OLS) because some lagged values are restricted to zeroes. The key results in the first paper are: the significant influence of international variables on New Zealand business cycle; the importance of separately identifying import price and export price shocks; and the significant influence of climate on the economy. In the second paper the authors were trying to address three questions: whether inflation-targeting in New Zealand has resulted in monetary policy accentuating or dampening business cycles; what was the impact of monetary policy on the variability of inflation; and the third one is whether monetary policy affects the trade-off between output and inflation variability. One interesting technique they use to gauge the impact of monetary policy on detrended GDP is the method used earlier by

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[33] As cited in Buckle et al. (2002).

[34] Defined as the percentage deviation of real GDP from its trend level (also known as the growth cycle).

[35] Because the official cash rate (OCR) was introduced recently, the authors use the 90-day rate as a proxy for the monetary policy instrument.

Dungey and Pagan (2000). They started off with the moving average representation of the VAR that shows detrended output as the summation of thirteen impulse responses due to the thirteen unique shocks in the entire model. This is represented as:

$$y_t = initial \;\; conditions + \sum_{i=0}^{t-1} \sum_{j=1}^{13} \theta_{ij} u_{j,t-i} \tag{3.15}$$

where y_t is the detrended output, θ_{ij} is the *i*th impulse response associated with the jth shock.

The authors claim that the detrended output is in fact affected by the direct impact (non-systematic) of interest rate as well as from the induced (systematic) impact. The latter arises when the central bank changes the interest rate in response to changes in the domestic economic environment, and this is captured by the reaction function. Therefore in order to estimate the induced impact they restricted the coefficients of domestic demand and domestic price to zero in the reaction function. The resulting equation is exactly like Equation 3.15 except now the impulse responses and the detrended output are slightly altered because of the restrictions imposed on the reaction function. Now to get the total effect of the monetary policy effect on detrended output they formulate the following equation.

$$MPI_t = \sum_{t=0}^{t-1} \theta^{*}_{t,10} u_{10,t-1} + \sum_{i=0}^{t-1} \sum_{j=1}^{13} (\theta_{ij} - \theta^{*}_{ij}) u_{j,t-i} \tag{3.16}$$

where MPI = monetary policy index
θ^{*}_{ij} = impulse response functions when the reaction function is suppressed

The first term on the right hand side measures the direct (non-systematic) reaction of monetary policy and the second component captures the systematic reaction of monetary policy to the different shocks. Therefore to get the profile for detrended GDP in the absence of a monetary policy response one needs to subtract Equation 3.16 from detrended GDP (y_t).

Buckle et al. (2003) findings are: under inflation-targeting monetary policy has tended to be countercyclical on New Zealand growth cycles and has tended to reduce inflation and output variability[36].

We will look next at some of the monetary transmission studies that have been done in Australia. Like New Zealand, not many empirical studies have been undertaken on the monetary transmission channels in Australia. There may be several reasons for this but as noted by Brischetto and Voss (1999) the use of the VAR models in Australia is fairly recent and this could be one reason why not many empirical studies have been undertaken in the past. One paper that looks specifically at the lending channel is that of Suzuki (2001). Other useful and interesting papers include that of Brischetto and Voss (1999), Dungey (2001), Dungey and Pagan (2000), Gruen et al. (1999) and Orden and Fisher (1993). These are summarised below.

Suzuki (2001) study looks at how a tightening monetary policy affects the bank loans. His approach is interesting in that he tries to separate the lending view from the conventional money view (or the interest rate channel). His claim is that the decline in aggregate demand following a tightening of monetary policy can be explained by either transmission view. This can be translated to a test of whether the shift in the Australian bank loan market following monetary tightening is in the demand or the supply schedule. To carry out the test, Suzuki includes the price and the quantity of bank loans in his VAR model. The intuition behind his test is fairly straightforward: if the supply curve shifts to the left, then the quantity of loans demanded will fall but its price will rise; but if the demand schedule for the loans shifts, then both the quantity and the price of the loans will decline. His VAR model includes eight variables: world price index (non-fuel commodity price index), price (CPI), output (real GDP), money supply (base money), interest rate (cash rate), exchange rate (US$/AUS$), loan price and bank loans. Of all the variables listed, the loan price measurement is the most complicated—this is because it is difficult to get data on interest rate on new loans. In view of the difficulty, Suzuki decided to use the 'diffusion index'. He estimated his VAR model over the period 1985:1 to 2000:2 using the recursive (or the Cholesky) decomposition to identify the structural shocks and the ordering of the variables

[36] An interesting and useful explanation of the benefit of countercyclical policy is provided by Chatterjee (2001).

is as listed. His finding is that the price and the quantity of loans initially increase but after a few quarters they both decline. This implies that the demand schedule for loans actually shifted—hence the lending channel view is not supported.

Orden and Fisher (1993) study is one of the earlier empirical works that utilizes the VAR framework to study the dynamic relationships between money, prices and output. In fact they use the error correction VAR form (i.e. VEC) because they found some significant cointegrating relationships prior to the financial liberalizations in the 1980s. It is also one of the few studies that compare Australia and New Zealand economies. Their principle findings are that shocks to money have very little effect on real output, while money and prices tend to move proportionally in the long run.

The paper by Brischetto and Voss (1999) examines the effects of monetary policy in Australia using an open economy structural VAR model that was first developed by Kim and Roubini (1999). Their impulse responses do not show the price and exchange rate puzzles typically encountered in other VAR studies and they claim the reason is because of the inclusion of the exchange rate and the foreign interest rate. They also claim that their model is satisfactory in terms of producing results that are consistent with existing structural VAR literature and with previous empirical work for Australia. Another related paper is by Dungey and Pagan (2000) who formulated a 11-variable structural VAR model of the Australian economy. The number of variables here is more than the seven variables of Brischetto and Voss (1999) model. Another difference in the two studies is the use of variables in level by Brischetto and Voss while Dungey and Pagan use a detrended[37] series. Also the focus of the two papers is slightly different. Brischetto and Voss study focuses more specifically on the effects of monetary policy while Dungey and Pagan study is more general in the sense that they try to formulate a model that captures most of the observed features of the real economy over time and behaves broadly as expected in response to various shocks. One of their important findings is that both foreign output and asset price effects play a major role in the Australian growth cycle. They also noted that the influence of monetary policy on the economy is seen to contribute to stabilizing activity but the effects are not large.

[37] By regressing on a constant and a deterministic trend.

A paper by Gruen et al. (1999) is unique and important in that it tries to estimate the length of the transmission lags from monetary policy to output. They use a single equation to estimate the effect of a one-percentage change in the short-term real interest rate on output growth over the subsequent three years. Their equation is given below.

$$\Delta y_t = \alpha + \sum_{j=0}^{6} \beta_j r_{t-j} + [\gamma_2 \Delta f_{t-2} + \gamma_4 \Delta f_{t-4}] + \delta y_{t-1} + \chi w_{t-1} + \sum_{j=o}^{1} \phi_j \Delta w_{t-j} + \varepsilon_t \qquad (3.17)$$

where y = non-farm output; w = US output; r = short-term real interest rate
f = farm output; ε_t = mean zero error term

They estimated two versions of the Equation 3.17. In the first version they use the real interest rate that is derived by subtracting the underlying CPI from the overnight cash rate and in the second version, they use the headline CPI. They included the US output because many studies in the past have documented the importance of the US economy and financial status on the Australian economy—they cited the works of McTaggart and Hall (1993), Gruen and Shuetrim (1994), de Roos and Russel (1996), Kortian and O'Regan (1996), Debelle and Preston (1995), de Brouwer and Romalis (1996). In their results, they reported the mean of the coefficients of the interest rate (β's) as negative and significant. More importantly they estimated the average monetary policy lag length as 6.4 quarters for the underlying CPI model and 5.8 quarters for the headline CPI model. In order to estimate these averages they use the following formula:

$$\frac{\sum_{i=1}^{\infty} (i-1).\Delta m_i}{\sum_{i=1}^{\infty} \Delta m_i} \qquad (3.18)$$

where m = is the effect on non-farm output growth in quarter *'i'*

While the authors managed to estimate the lags of the monetary policy[38] they did emphasise the problems associated with the technique, like the endogeneity of interest rate to output changes or the sensitivity of their test to the type of inflation rate they use. As they pointed out in their conclusion, "*All these estimates are, however, subject to considerable uncertainty*".

[38] An interesting nonparametric analysis of the monetary policy lags is presented by Uselton (1974).

3.5 Summary

From the literature review it is quite clear that the list of empirical studies both in monetary neutrality and in the transmission field in New Zealand and in Australia is fairly limited. It is also quite obvious from the neutrality studies reviewed that virtually no study has been conducted on the short run responses—i.e. most studies just concentrate on the long-run analysis, despite the availability of suitable techniques and the importance of such evidence in economic theories. Furthermore, the review on the monetary transmission studies shows that virtually no study has been undertaken that looked at the monetary transmission channels as a whole, i.e. starting from the money supply, then moving on to interest rate, investment and finally output. Most of the studies either take a 'short-cut' by examining the direct impact of monetary policy on output (or inflation), without actually spending time on the intermediate or 'inner' workings of the system (the part the literature usually refers to as the 'black box') or they simply look at partial or incomplete parts of the transmission system—as in studies that look exclusively at the impact of interest rate on exchange rate or the effect of interest rate on investment, and so forth. Comparative studies among the different transmission channels and among different countries is very limited also. This thesis is meant to address some of the shortcomings just described, in particular it will incorporate short run analysis in the neutrality tests; will try to systematically analyse and understand each transmission mechanism, starting from the money supply and moving sequentially through the relevant variables until the last variable, output—at least in accordance with the known theoretical models that Mishkin (1995) and Kuttner and Mosser (2002) have discussed; and finally will compare the effectiveness or responsiveness of the monetary transmission between Australia and New Zealand. Central to the analysis is the idea of presenting numerical and graphical results to facilitate the discussion as well as providing quantitative measurements that could be of use to policy-makers who need more than just the 'qualitative' conclusions from empirical studies.

Aside from the shortcomings or the gaps in the literature summarised above, the following will briefly highlight some of the prevalent and important themes emerging from the review. First, the interest on studying the monetary transmission is evidently growing among many nations, in particular in Europe following the creation of the Eurosystem[39] in 1999. And among the monetary transmission channels, the credit channel seems to be attracting a lot of empirical researches in recent years. Secondly, many researchers are using the VAR (or VEC) framework as their analytical model but while some studies are adopting the structural identification approach, many studies are still using the Cholesky or recursive identification scheme. Some recent researches have noted the importance of the international factors both in producing consistent responses as well as in eliminating previous empirical puzzles, such as the price or exchange rate puzzles. Finally it is quite evident that there are still many questions left unresolved and which may be summarised in Norrbin (2000) concluding statement: *The reviewed literature indicates that we have so far learned very little about the empirical transmission effects of money. Although the literature is voluminous, little agreement exists on the exact variables that cause the transmission mechanism.* As hinted above, this thesis is meant to provide empirical evidence on the workings of the different transmission mechanisms with particular focus on the bivariate relationships within each monetary transmission channel.

[39] See, for example, Cecchetti (1999).

Chapter 4

ECONOMETRIC ISSUES

4.1 Introduction

Because the empirical analysis is based mainly on the vector autoregression (or VAR) framework, it is important that the econometric issues and specialized constructs associated with this analytical framework are described/explained in order for one to be appreciative of the methods/techniques involved; how the results are obtained; what are the limitations/shortcomings; and generally to follow the analysis and interpretations made. With the ever increasing power and 'friendliness' of computer packages these days, one can easily get econometric results virtually with a single press on the computer keyboard, but the results would be meaningless if one is not fully conversant with the econometric issues involved, such as nonstationarity, cointegration, variance decomposition, stability, and so forth. The aim of this chapter therefore is to explain some of the econometric issues or constructs that are considered pertinent to the VAR analysis intended for this study. It is important however to emphasise that some of the issues/constructs are fairly complex and their description or explanation here may not be adequate to give a complete insight into the subject, in which case relevant econometric text books should be consulted.

4.2 Unit root (nonstationary) issue

One very important reason why the presence of a unit root needs to be determined in the early part of a VAR analysis is because the response of a variable having a unit root (i.e. a nonstationary variable) to exogenous shocks is very different to the response of a stationary series to the same shocks. That is, the effect of a shock on the nonstationary variable is sustained, i.e. permanent, while the effect on the stationary variable quickly dies away. This is possible because the variable with a unit-root can be inverted to an infinite moving average (VMA) representation, i.e. a sequence of error terms that virtually goes to infinity—hence a shock, or change to the error term, will always be reflected in the value of the variable in principle[1]. This is demonstrated below using a simple autoregressive process (AR)—such as an AR(1) process.

[1] In sample data the effect will eventually dies out—in the literature, processes exhibiting this characteristic are often referred to as having 'long' memory.

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \varepsilon_t \qquad where\ \varepsilon_t \sim N(0,\sigma^2) \tag{4.1}$$

$$and\ since\ y_{t-1} = \alpha_0 + \alpha_1 y_{t-2} + \varepsilon_{t-1}$$

$$we\ can\ substitute\ y_{t-1}\ in\ equation\ (4.1)\ and\ get$$

$$y_t = \alpha_0 + \alpha_1(\alpha_0 + \alpha_1 y_{t-2} + \varepsilon_{t-1}) + \varepsilon_t$$

$$= \alpha_0 + \alpha_1\alpha_0 + \alpha_1^2\ y_{t-2} + \alpha_1\varepsilon_{t-1} + \varepsilon_t$$

$$and\ if\ we\ continue\ substituting\ y\ lags\ we\ get$$

$$y_t = \sum_{i=0} \alpha_0\alpha_1^i + \sum_{i=0} \alpha_1^i\varepsilon_{t-i} \tag{4.2}$$

so if $\alpha_1 = 1$, *i.e. unit root process, then we get*

$$y_t = \alpha_0 n + \sum_{i=0}^{\infty} \varepsilon_{t-i} = const + \varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \varepsilon_{t-3} + \dots\dots\dots \tag{4.3}$$

The AR(1) process is shown in (4.1) while (4.3) is an infinite moving average representation. What is important here is that when there is an exogenous shock to the series, then the current disturbance (ε_t) will change and this change will be reflected in all subsequent values of the y_t series because the shock will constitute part of the summation and will never disappear, i.e. the series is said to have undergone a 'permanent' change[2]. If α_1 is less than one, then any change in the shock term will disappear over time because the coefficient α_1^i will go to zero as $i \to \infty$, i.e. the impact of the shock will gradually disappear over time. When this occurs, the series is said to be stationary or has no unit root.

Testing for a unit-root is not very straightforward because of the possibility that the series in question may have a trend, a constant or both, in which case the appropriate testing procedure is required, i.e. one that takes into account the presence of these deterministic regressors. Dickey and Fuller (1979)[3] consider three formulations or regressions that can be used to test unit root in a time series data. The first is where the regression includes a 'time trend and a constant'; the second is where only a 'constant' is included; and the third where

[2] In real situations, a 'permanent' change is very difficult to observe because most of the economic variables will keep changing from period to period so the possibility of a getting a 'permanent' change in a series is a very useful concept and in fact provides the basis for Fish and Seater (1993) long run neutrality test.

[3] As cited in Enders (1995, p. 221).

none of these deterministic regressors is incorporated. The general testing approach is to start with the most unrestricted formulation (i.e. one with the 'trend and the constant') and then move to the next equation with only the 'constant' included, and finally ending up with the most restricted form which has neither the trend nor the constant regressor[4]. At any time the null hypothesis of nonstationary is rejected, the test will stop and the conclusion is that the series has no unit root, i.e. stationary. The three regressions are shown in (4.4) to (4.6). Note when the lags of the differenced-variable are added in order to absorb any serial correlation, the testing procedure is known as the Augmented Dickey Fuller test.

$$\Delta y_t = \alpha_0 + \gamma\ y_{t-1} + \alpha_2 t + \Sigma\beta_i \Delta y_{t-i-1} + \varepsilon_t \tag{4.4}$$

$$\Delta y_t = \alpha_0 + \gamma\ y_{t-1} + \Sigma\beta_i \Delta y_{t-i-1} + \varepsilon_t \tag{4.5}$$

$$\Delta y_t = \gamma\, y_{t-1} + \Sigma\beta_i \Delta y_{t-i-1} + \varepsilon_t \tag{4.6}$$

The critical values for the test regressions are often denoted as τ_τ, τ_μ and τ, respectively, and are dependent on whether a constant (or intercept) and/or time trend are included, i.e. using τ_τ when the model has no trend could give wrong conclusions, likewise τ should be used when there is no constant and time trend in the equation.

Obviously there are several hypotheses that can be tested from the three equations (4.4)-(4.6) but the most important one is the unit root hypothesis: $\gamma = 0$[5]. The other testable hypotheses include testing for the significance of the trend term under the null hypothesis or testing the significance of the constant term.

There are several unit root tests that are currently used but for this study the following three tests will be used: the Augmented Dickey Fuller (ADF), the Phillips-Perron (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests[6]. The ADF and PP tests both use the null hypothesis of nonstationary (or $\gamma = 0$) however the ADF test assumes the errors are statistically independent and have constant variance while the PP test assumes a more

[4] In line with Hendry general-to-specific approach.

[5] Actually $\gamma = \alpha_1 - 1$ after subtracting y_{t-1} from both sides of Equation (4.1), i.e. $\gamma = 0$ means $\alpha_1 = 1$ (i.e. nonstationary).

[6] Using several tests, in particular a mix of tests, some with the null of nonstationary and others with the stationary null, is known as 'confirmatory' analysis (Maddala, 2001).

flexible distribution for the error terms (see Enders (1995, p. 239)). It is also useful to mention here that under the null hypothesis (i.e.,$\gamma = 0$), the series is assumed nonstationary hence the distribution of the parameter γ does not follow the standard t-distribution, nor the asymptotically normal distribution N(0,1)[7]. Dickey and Fuller, however, have generated relevant critical statistics using Monte Carlo simulation. The KPPS test, on the other hand, uses the null of 'stationary'. This test relies on the following equation:

$$y_t = \beta t + x_t + \varepsilon_t \tag{4.7}$$

where ε_t is a stationary process

$$\text{and } x_t = x_{t-1} + u_t, \text{ where } u_t \sim iid(0, \sigma_u^2) \tag{4.8}$$

And the null hypothesis of stationary is formulated as:

H$_0$: $\sigma_u^2 = 0$ or x_t is a constant (because it does not vary), against the alternative hypothesis Ha: $\sigma_u^2 > 0$

This is a test of parameter constancy against the alternative that the parameters follow a random walk, i.e. if we reject the null hypothesis then the parameters follow a random walk (or unit root process).

To finish off the discussion on the unit root tests, it is important to note that the 'power' of these unit root tests is generally low, meaning that they often do not reject the null hypothesis when it is wrong[8], i.e. these tests do not have the power to distinguish unit root processes and near unit-root processes. Moreover they have little power to distinguish between trend stationary and drifting processes[9].

4.3 Seasonal unit root

As pointed out by Enders (1995, p. 229) seasonality is a key feature of many economic series. This means that there is a regular pattern in the series that occur or follow some regular time period, say every month, quarter or once a year. In view of this, it may not be possible to get a stationary series by simply taking first-differences, i.e., for quarterly data it may be necessary to subtract the value of y_t not by y_{t-1} but by y_{t-4} to get a stationary series. One method for testing seasonal unit root will be illustrated here. This test is attributed to

[7] Discussed in Johnston and Dinardo (1997, p. 224) and in Enders (1995, p. 212)
[8] According to Keating (1992) because of the their low power, the existence of unit roots is controversial.
[9] Drifting process is a difference-stationary process, i.e. a random walk with a constant (or drift term).

Hylleberg, Engle, Granger and Yoo (1990) as cited in Enders (1995, p. 232) and in Maddala and Kim (1998, p. 367).

$$\Delta_4 y_t = \sum_{s=1}^{4} \alpha_s D_{st} + \gamma T + \pi_1 y_{1,t-1} + \pi_2 y_{2,t-1} + \pi_3 y_{3,t-2} + \pi_4 y_{3,t-1} + \sum_{i=1}^{k} \phi_i \Delta_4 y_{t-i} + \varepsilon_t \quad (4.9)$$

where D_{st} are seasonal dummies, T is the trend and

$$\Delta_4 y_t = y_t - y_{t-4}$$
$$y_{1,t-1} = y_{t-1} + y_{t-2} + y_{t-3} + y_{t-4}$$
$$y_{2,t-1} = y_{t-1} - y_{t-2} + y_{t-3} - y_{t-4}$$
$$y_{3,t-1} = y_{t-1} - y_{t-3}$$
$$y_{3,t-2} = y_{t-2} - y_{t-4}$$

and $\varepsilon_t \sim N(0,\sigma^2)$

Note: if the constant is included then only three seasonal dummies will be used; these dummies are used to take care of the 'deterministic' seasonal factors.

The above formulation tests for unit roots at various frequencies, namely, zero frequency, semiannual frequency, and annual frequency. If $\pi_1 = 0$, the series contains a unit root at zero frequency, i.e., the series contains a nonseasonal unit root. If $\pi_2 = 0$, there is seasonal unit root at semiannual frequency, and if $\pi_3 = 0$ and $\pi_4 = 0$ then there is a seasonal unit root at annual frequency. If $\pi_1 = 0$, then the appropriate filter is *(1 - L)*, and if $\pi_2 = 0$, then the filter is (*1* + *L*), and if $\pi_3 = 0$ and $\pi_4 = 0$, then the filter is (*1* + L^2).

4.4 Stability

The issue of stability is related to stationary, and is crucial for the Fish and Seater (1993) long-run neutrality test (LRD) because a VAR that is stable converges, meaning that it is possible to get the long-run multipliers that the test requires. In a univariate system, to be stationary the essential criteria is for the coefficient of the lagged variable to be less than unity—otherwise the series is said to have a unit root or is non-stationary. In the VAR context, the principle still holds though the expression is getting a bit more complicated because instead of a single scalar coefficient, we are now dealing with a matrix and characteristic roots. In order to illustrate this we will use the first order bivariate VAR[10]. We start off with the reduced form VAR.

$$y_t = a_{10} + a_{11}y_{t-1} + a_{12}m_{t-1} + e_{1t} \tag{4.10}$$

$$m_t = a_{20} + a_{21}y_{t-1} + a_{22}m_{t-1} + e_{2t} \tag{4.11}$$

Using lag operators (L), we get:

$$y_t = a_{10} + a_{11}Ly_t + a_{12}Lm_t + e_{1t} \tag{4.12}$$

$$m_t = a_{20} + a_{21}Ly_t + a_{22}Lm_t + e_{2t} \tag{4.13}$$

And rearranging as to put the same variables together:

$$(1 - a_{11}L)y_t = a_{10} + a_{12}Lm_t + e_{1t} \tag{4.14}$$

$$(1 - a_{22}L)m_t = a_{20} + a_{21}Ly_t + e_{2t} \tag{4.15}$$

And using equation 4.13 to get m_t,

$$m_t = \frac{a_{20} + a_{21}Ly_t + e_{2t}}{(1 - a_{22}L)} \tag{4.16}$$

So substituting m_t into (4.12), in order to solve for y_t:

$$(1 - a_{11}L)y_t = a_{10} + a_{12}L\left(\frac{a_{20} + a_{21}Ly_t + e_{2t}}{1 - a_{22}L}\right) + e_{1t} \tag{4.17}$$

$$(1 - a_{11}L)y_t = \frac{a_{10}(1 - a_{22}L) + a_{12}a_{20}L + a_{12}a_{21}L^2y_t + a_{12}Le_{2t} + e_{1t}(1 - a_{22}L)}{1 - a_{22}L} \tag{4.18}$$

$$(1 - a_{11}L)y_t - \frac{a_{12}a_{21}L^2y_t}{1 - a_{22}L} = \frac{a_{10}(1 - a_{22}L) + a_{12}a_{20}L + a_{12}Le_{2t} + e_{1t}(1 - a_{22}L)}{1 - a_{22}L} \tag{4.19}$$

$$\frac{y_t[(1 - a_{22}L)(1 - a_{11}L) - a_{12}a_{21}L^2]}{1 - a_{22}L} = \frac{a_{10}(1 - a_{22}L) + a_{12}a_{20}L + a_{12}Le_{2t} + e_{1t}(1 - a_{22}L)}{1 - a_{22}L} \tag{4.20}$$

So the explicit solution of y_t is:

$$y_t = \frac{a_{10}(1 - a_{22}) + a_{12}a_{20} + a_{12}e_{2t-1} + e_{1t}(1 - a_{22}L)}{(1 - a_{22}L)(1 - a_{11}L) - a_{12}a_{21}L^2} \tag{4.21}$$

The solution for m_t can be determined in the same way as for y_t. In terms of the stability condition, the polynomial in the denominator in (4.21), known as the characteristic equation, should have roots that are greater than one, or should lie outside the unit circle. The inverse of these roots are called the characteristic roots of the solutions for the series (y_t

[10] This basically follows the approach in Enders (1995, p. 298) but the illustration here has been extended further with more algebraic expressions included as to show more clearly the steps involved. Note also that this illustration can be generalized to higher order VARs though the algebra may get a bit more 'messy'.

and m_t), and logically must be less than unity for the system to be stable or convergent. In most empirical studies, the characteristic roots are calculated by computer packages because of the extensive and tedious algebraic manipulations involved[11].

4.5 Structural breaks

Structural breaks are important because they may coincide with major events, like major policy shift, international crisis, or natural catastrophes, thus raising the possibility of changing the stylised facts of a country[12]. Furthermore, these breaks may affect model estimation and forecasting—as pointed out by Mahadeva and Sinclair (2002, p.7), *"The presence of structural breaks implies a model passing all these tests[13] on past data need not necessarily forecast the future well"*. In other words, forecast may be inaccurate if there are structural breaks in the data. Another important reason for checking for structural breaks is that the presence of one or more will bias the results of unit root tests towards non-rejection of stochastic nonstationary (or unit root) null hypothesis[14]. There are several tests for structural breaks, such as the Chow's Breakpoint test and the CUSUM test of Brown, Durbin and Evans (1975) but in this study, Perron's test will be applied because the series are nonstationary. Perron (1989) suggests three hypothesis formulations which he labels as: model A, B and C, however the approach here will use the composite equation that combines all the different hypotheses—as is done in Sanyal and Ward (1995). The combined equation is shown below.

$$Y_t = u + \alpha Y_{t-1} + \beta t + \gamma_1 DUP + \gamma_2 DUL + \gamma_3 DUS + \sum_{1}^{k} \eta_t \Delta(Y_{t-1}) + e_t \tag{4.22}$$

where DUP, DUL and DUS are the dummy variables,

DUP= pulse dummy variable=1 when t=Tb+1 (and 0 otherwise)

DUL=level dummy variable=1 when t> Tb (and 0 otherwise)

DUS= slope dummy variable=t-Tb if t>Tb (and 0 otherwise)

e_t is assumed to be independently distributed with zero mean and constant variance

and Tb is the structural break point, and the lagged first difference term is included in order to absorb any serial correlation (see Enders, 1994, p.247).

[11] Some of these can be seen in A7.2.1 in the appendix.

[12] Sanyal and Ward (1995) investigate this topic using New Zealand data.

[13] Referring to the three criteria for a 'good' model, viz., accurate forecast; immune to the Lucas critique; and to be based on reliable data.

[14] Perron (1989) paper gives a strong argument against the view that most economic variables have unit root, in particular counters the finding of Nelson and Plosser (1982) and insists that most variables are stationary around a deterministic trend if allowance is made for the structural breaks within the data series. This topic is also discussed in Enders (1995) and Maddala and Kim (1998).

Note that the break point (Tb) can be exogenously provided, as is done in the original Perron (1989) study and more recently in Donganlar (1998). Some studies, however, like that of Sanyal and Ward (1995), Zivot and Andrews (1992), Perron (1997), Debs (2001), among others, use endogenously determined break points.

Equation (4.22) is a very general expression for a process that is stationary around a trend function with a break in (i) both in level and slope if $\gamma_2 \neq 0$; $\gamma_3 \neq 0$; $\beta \neq 0$; and $\alpha < 1$ *and* $\gamma_1 \approx 0$, (ii) in just its level if $\gamma_3 = 0$; $\alpha < 1$ *and* $\gamma_1 \approx 0$, and just its slope when $\gamma_2 = 0$; *and* $\alpha < 1$ *and* $\gamma_1 \approx 0$. The null hypothesis, on the other hand, can be written as:

$$Y_t = u + \alpha Y_{t-1} + \gamma_1 DUP + \sum_{1}^{k} \eta_t \Delta(Y_{t-1}) + e_t \tag{4.23}$$

$$where\ \alpha = 1\ \ and\ \ \gamma_1 \neq 0.$$

The above equation should be estimated using OLS and the null hypothesis Ho: $\alpha = 1$ (i.e. unit root) should be tested against the alternative hypothesis, Ha: $\alpha < 1$ (i.e. no unit root). Now under the null hypothesis, the distribution of α does not follow the standard t-distribution but its asymptotic critical values, designated as $t(\hat{\alpha})$, has been tabulated by Perron (1989). If we reject the null hypothesis, it means that the series has no stochastic trend and consequently the three coefficients of the trend, the level dummy and the slope dummy, i.e. β, γ_2 *and* γ_3, can be tested for their significance using the standard 't' test.

4.6 Cointegration

Cointegration is said to occur between nonstationary variables when their linear combinations are stationary. Although the concept of cointegration was introduced sometime ago by Granger (1980)[15] its application and use is relatively new. Enders (1995, p.355) reports, *"This chapter[16] explores an exciting new development in econometrics: the estimation of a structural equation or VAR containing nonstationary variables"* and Thomas (1993, p.171) says, *"Cointegration analysis, its relationships to ECMs and its use*

[15] As cited in Maddalla and Kim (1998, p. 26).
[16] Referring to the 'Cointegration and Error Correction Model" chapter.

in conjunction with the Hendry-type testing down procedure is a relatively new but exciting development in econometrics".

When there is evidence of cointegration between the variables, the VAR model should incorporate the 'error correction term' in order to specify correctly the model. This error correction term is stationary (by definition) and so the classical assumption for linear regression is not violated. Therefore before the VAR model is estimated the variables should be tested first for cointegration. If there is no cointegration relationship detected, the error correction term should not be included and the model is a straightforward traditional VAR. It should be emphasised that cointegration analysis is only applicable when variables are nonstationary in level and also when they are of the same order of integration.

Two common tests for cointegration relationships are the Engle-Granger methodology and that of Johansen. In this analysis the latter approach will be used. This is because the Engle-Granger method has several defects, namely the determination of the residuals is not invariant to the way the normalisation is done and secondly it relies on a two-step estimator[17]. Also it does not distinguish between the existence of one or more cointegrating vectors (Hafer and Jansen, 1991). The Johansen test, on the other hand, relies on the relationship between the rank of a matrix and its characteristics roots and generally overcomes most of the problems associated with the Engle-Granger test procedure. Some of these features will be elaborated below with the aid of a simple bivariate VAR model.

Now to apply the Johansen test[18], we need to find first the order of integration of the variables (say y_t and m_t in our example). Once we are satisfied that all variables are integrated of the same order[19], we then proceed to test for the lag length. The important criteria for this lag test is to ensure that the residuals of the equations (4.24 or 4.25) are serially uncorrelated and homoscedastic.

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[17] See Enders (1995, p. 385) for more discussion on this.

[18] This depends on the maximum likelihood estimation procedure--as opposed to the Engle-Granger test that uses the OLS method.

[19] This can be done using the normal unit root tests, such as the augmented Dickey-Fuller or the Phillips-Perron test.

$$\begin{bmatrix} y_t \\ m_t \end{bmatrix} = \begin{bmatrix} a_{01} \\ a_{02} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} y_{t-1} \\ m_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{13} & \beta_{14} \\ \beta_{23} & \beta_{24} \end{bmatrix} \begin{bmatrix} y_{t-2} \\ m_{t-2} \end{bmatrix} + \dots\dots\dots\dots + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{mt} \end{bmatrix} \tag{4.24}$$

or in more compact form:

$$X_t = A_0 + B_1 X_{t-1} + B_2 X_{t-2} + B_3 X_{t-3} + \dots\dots\dots + \varepsilon_t \tag{4.25}$$

where X_t is vector of endogenous variables, and generally are in level.

There are several versions of the lag test. One approach is where we estimate a VAR with many lags, say 8 lags, and then estimate the same VAR but with a smaller number of lags, say 4 lags, and then compare these two models. In this instance we refer to the larger VAR as the 'unrestricted' model while the smaller VAR is the 'restricted' version because the test statistic that we will use is the likelihood ratio test that requires both estimates of the 'unrestricted' and the 'restricted' model. The underlying philosophy of this test is simply to see whether the restrictions imposed when we use the shorter VAR has changed the maximized likelihood function significantly, i.e. the null hypothesis under valid restrictions is that the maximized likelihood of the unrestricted and the restricted models should be very similar. The test statistic formula is given below:

$$(T - c)(\log|\Sigma_4| - \log|\Sigma_8|) \tag{4.26}$$

where T = number of observations
c = number of parameters in the unrestricted system
Σ_i = variance-covariance matrix of the residuals
$\log|\Sigma_i|$ = natural logarithm of the determinant of Σ_i.

The likelihood ratio test statistic has the asymptotic χ^2 distribution with the degrees of freedom equals to the number of restrictions in the system, which in our example will be $4n^2$ or $4(2)^2 = 16$. The other two common tests are the multivariate versions of the Akaike information criterion (AIC) and Schwartz Bayesian criterion (SBC) tests, calculated as:

$$\begin{aligned} AIC &= T\log|\Sigma| + 2N \\ SBC &= T\log|\Sigma| + N\log(T) \end{aligned} \tag{4.27}$$

where $|\Sigma|$ = determinant of the variance/covariance matrix of the residuals
N = total number of parameters estimated in all equations
T = total number of usable information

The two important criteria underlying the tests above are: the residual sum of squares should be minimal and the model should be as parsimonious as possible[20]. In other words, the model with the lowest AIC or SBC should be selected.

Once the number of lags is determined the next important step in the Johansen method is to estimate the 'error correction' or VEC model and then determine the rank of the Π matrix. The model to be estimated is given in (4.28) below. Note here that OLS cannot be used because of the contemporaneous relationships (or restrictions) that can be imposed on the Π matrix.

$$\Delta x_t = A_0 + \Pi x_{t-1} + B_1 \Delta x_{t-1} + B_2 \Delta x_{t-2} + \dots\dots + \varepsilon_t \qquad (4.28)$$

where x_t is vector of nonstationary variables

$\Pi = \alpha\beta = A_1 - I$

and ε_t is a vector of 'white noise' residuals which may be cross-correlated

In order to have a more clear idea of what constitutes the different terms shown in (4.28), it is useful to have an expanded representation of (4.28) so that it is easier to comprehend what is being discussed. Again, in order to make the exposition simple, a bivariate model is used. This is shown below, and because of space constraint, only one lag is used.

$$\begin{bmatrix} \Delta y_t \\ \Delta m_t \end{bmatrix} = \begin{bmatrix} a_{01} \\ a_{02} \end{bmatrix} + \begin{bmatrix} \alpha_y \beta_1 & \alpha_y \beta_2 \\ \alpha_m \beta_1 & \alpha_m \beta_2 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ m_{t-1} \end{bmatrix} + \begin{bmatrix} \beta_{11}(1) & \beta_{12}(1) \\ \beta_{21}(1) & \beta_{22}(1) \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta m_{t-1} \end{bmatrix} + + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{mt} \end{bmatrix} \qquad (4.29)$$

where the cointegrating vector is (β_1, β_2) and the speed of adjustments are α_y and α_m

Once the model has been estimated, the next task is to calculate the characteristic roots (or eigenvalues) of the Π matrix. This is achieved by equating the determinant[21] of the Π matrix to zero[22] and solving for the roots, λ_1 *and* λ_2[23]. The number of these nonzero characteristic roots is equal to the rank of the matrix that in turn is equal to the number of cointegrating vectors. The key feature of Johansen test is the relationship between the rank

[20] It is important however that the residuals are normally distributed, non-serially correlated and homoscedastic , i.e. white noise process.

[21] A well-illustrated exposition of the relevant matrix algebra, including determinants, is provided in the first chapter of Greene (1993).

[22] Like this: $| A - \lambda I|=0$.

[23] For higher order VARs, there will more roots.

of Π matrix and its characteristics roots so to understand this relationship a numerical example will be given below—again using our bivariate example. Let us assume the Π matrix has been estimated:

$$\Pi = \begin{bmatrix} 0.5 & -0.2 \\ -0.2 & 0.5 \end{bmatrix}$$

Our next task now is to find the characteristic roots of the above coefficient matrix. In order to do this we need to modify first the Π matrix by introducing the λ scalar. We then equate the determinant of this modified Π matrix to zero in order to solve for λ (which is in fact the characteristic root or eigenvalue).

$$\begin{vmatrix} 0.5-\lambda & -0.2 \\ -0.2 & 0.5-\lambda \end{vmatrix} = 0$$

To solve for λ we derive the characteristic equation.

$$(0.5-\lambda)(0.5-\lambda)-0.04=0$$

or

$$0.25-0.5\lambda-0.5\lambda+\lambda^2-0.04=0$$

or

$$\lambda^2-\lambda+0.21=0 \tag{4.30}$$

Solving the above equation using the quadratic rule or simple factorization yields the two roots: $\lambda_1 = 0.7$ and $\lambda_2 = 0.3$[24].

Now that we have determined the values of the two characteristic roots, the next question is: are they significantly different to zero or not? This is important because the number of nonzero roots is equal to the rank of the matrix, and the rank of the matrix is equal to the number of cointegrating vectors in the model. The Johansen test allows us to determine the number of roots that are significantly different from zero. To check this number, the two tests commonly used are the trace test and the maximum eigenvalue test. These are given below.

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[24] Note that 0.7 x 0.3 = 0.21 which is equal to the constant in the characteristic equation (4.30). This number is also equal to the determinant of the Π matrix, i.e. $|\Pi| = \prod_{i=1}^{n} \lambda_i = \lambda_1 x \lambda_2 x \ldots \lambda_n$.

$$\lambda_{trace}(r) = -T\sum \ln(1-\hat{\lambda}_i) \tag{4.31}$$

$$\lambda_{\max}(r, r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \tag{4.32}$$

where 'r' = the number of cointegrating vectors,

$\hat{\lambda}_i$ = the estimated values of the characteristic roots (eigenvalues) obtained from the estimated Π matrix

T = the number of observations

In both tests, testing the null hypothesis is carried out in a sequential fashion. For instance, in the trace test, the first null hypothesis to be tested is r = 0 (i.e. no cointegration) against the alternative that r > 0 (i.e. there is cointegration). If we reject the null of no cointegration we move to the 'next' null of r ≤ 1 (i.e. there is at the most one cointegration relationship) against the alternative of more than one cointegrating relationship. Now with regard to the maximum eigenvalue test, both the null and the alternative hypotheses are more specific. For instance, the null hypothesis says r = k whereas the alternative says, r = k+1. Using a numerical example, when the null is r = 0 (i.e. no cointegration relationship), the alternative says, r = 1 (there is one cointegrating relationship). So when we reject the null of no cointegration (r = 0) we move up to the next null of r = 1, but if we reject this null again, we move up to the null of r = 2. We keep doing this until we cannot reject the null hypothesis any more—in practice though the number of cointegrating vectors is quite small so we do not need to keep repeating this process many times.

Now going back to our example with the two characteristic roots, $\lambda_1 = 0.7$ and $\lambda_2 = 0.3$, we need now to apply the trace and the maximum eigenvalue tests in order to determine the number of cointegrating vectors. We assume $T = 40$ just for illustrative purposes.

Trace test:

$$\begin{aligned}\lambda_{trace}(0) &= -T[\ln(1-\lambda_1) + \ln(1-\lambda_2)] \\ &= 40[\ln(1-0.7) + \ln(1-0.3)] \\ &= 62.4\end{aligned}$$

$$\begin{aligned}\lambda_{trace}(1) &= -T[\ln(1-\lambda_2)] \\ &= 40[\ln(1-0.3)] \\ &= 14.3\end{aligned}$$

Maximum eigenvalue test:

$$\lambda_{\max}(0) = -T\ln(1-\lambda_1)$$
$$= 40\ln(1-0.7)$$
$$= 48.2$$
$$\lambda_{\max}(1) = -T\ln(1-\lambda_2)$$
$$= 40\ln(1-0.3)$$
$$=14.3$$

So comparing the trace test statistics above with the critical values[25] of 17.844 and 8.083 from the model 'without trend and constant' at the 95 per cent confidence level, we reject the null hypothesis of $r \leq 1$ and conclude that there are more than one cointegrating relationship. If we look at the maximum eigenvalue critical values of 14.595 and 8.083, we do reject the null hypothesis r = 1 and accept the alternative that r = 2, i.e. there are two cointegrating vectors which is consistent with the finding of the trace test. Now that we have tested and confirmed the presence of two cointegration relationships between the two variables, we can go ahead and re-estimate the model as a vector error correction model (VEC) with two cointegrating vectors rather than a straightforward VAR model.

Another useful representation of the estimated VEC model is given below. Note the constant in the error-correction term is suppressed because of space consideration.

$$\Delta y_t = a_{o1} + \alpha_y(y_{t-1} - \beta_2 m_{t-1}) + \sum_{i=1} \alpha_{11}(i)\Delta y_{t-i} + \sum \alpha_{12}(i)\Delta m_{t-i} + \varepsilon_{yt} \quad (4.33)$$

$$\Delta m_t = a_{02} + \alpha_m(y_{t-1} - \beta_2 m_{t-1}) + \sum_{i=1} \alpha_{21}(i)\Delta y_{t-i} + \sum \alpha_{22}(i)\Delta m_{t-i} + \varepsilon_{mt} \quad (4.34)$$

The normalisation of the cointegrating vector is made with respect to y_{t-1} (i.e. β_1 is set to unity) —but this can be done on m_{t-1} as well. One interesting and useful feature of the Johansen approach is that restrictions can be imposed (and tested) on the cointegrating vectors. These restrictions might relate to economic long run economic relationships. In view of this important and useful feature, some researchers might spent more time on analysing the cointegrating vectors and their speed of adjustments—and testing different restrictions, while others may wish to continue onto the innovation accounting techniques such as the impulse response function, forecast error decomposition and Granger-causality analysis. In this study, the focus is more on the innovation accounting techniques rather

[25] Using Table B in Enders (1995, p. 420)

than on the cointegration relationships hence no restrictions will be imposed on the cointegrating vectors and no analysis made on the speed of adjustment parameters.

4.7 Impulse Response Function

This is an important toolkit within the VAR framework and shows the direct relationships between endogenous variables and reduced or structural shocks. To see how these functions are derived we start off with the reduced form VAR with a lag of one[26].

$$x_t = A_0 + A_1 x_{t-1} + e_t \tag{4.35}$$

where x_t = vector of endogenous variables
A_o = matrix of constants, A_1 = coefficient matrix of the lagged variables
e_t = vector of residuals which are not serially correlated, though they may be cross-correlated

And since $x_{t-1} = A_0 + A_1 x_{t-2} + e_{t-1}$, we can substitute this in (4.35) and get:

$$x_t = A_0 + A_1(A_0 + A_1 x_{t-2} + e_{t-1}) + e_t$$

or

$$x_t = A_0 + A_1 A_0 + A_1^2 x_{t-2} + A_1 e_{t-1} + e_t$$

$$x_t = (I + A_1)A_0 + A_1^2 x_{t-2} + A_1 e_{t-1} + e_t$$

And if we continue this backward substitution, there will be no more values for the vector of lagged variables ($A_1^n x_{t-n}$) left—i.e. only the vector of residuals will remain with the vector of the constants, as shown below:

$$x_t = (I + A_1 + A_1^2 + A_1^3 + \dots + A_1^n)A_0 + A_1^n e_{t-n} + A_1^{n-1} e_{t-n-1} + \dots\dots\dots + A_1 e_{t-1} + e_t$$

or using the summation sign, we get

$$x_t = (I + A_1 + A_1^2 + A_1^3 + \dots + A_1^n)A_0 + \sum_{i=0}^{\infty} A_1^i e_{t-i} \tag{4.36}$$

And if we assume the stability condition is met[27], then the solution is given by:

$$x_t = \mu + \sum_{i=0}^{\infty} A_1^i e_{t-i} \tag{4.37}$$

Now the above equation expresses the relationship between the vector of endogenous variables x_t and the reduced form residuals e_t. The problem with this is that the error terms

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[26] In actual fact there could be more lags but to simplify the exposition only one lag will be used. Also whether the variable is in level or in first-difference is not important at this stage. The expositions here and that of the variance decomposition are based on Enders (1995).

[27] See sub-Chapter 4.4 for the conditions for stability.

are correlated across the equations so in order to get independent or structural shocks, which are obviously of more interest, we need to transform these reduced form error terms into independent or orthogonal shocks. The process of transforming these reduced form errors is naturally called *orthogonalisation* but the system needs to be identified[28].

To make the transformation recall the structural (or primitive) VAR format

$$Bx_t = C_0 + C_1 x_{t-1} + \varepsilon_t \tag{4.38}$$

And when we premultiply each side by B^{-1} we get,

$$x_t = B^{-1}C_0 + B^{-1}C_1 x_{t-1} + B^{-1}\varepsilon_t \tag{4.39}$$

This is the reduced form and can be rewritten as

$$x_t = A_0 + A_1 x_{t-1} + e_t$$

$$\textit{where } A_0 = B^{-1}C_0,\ A_1 = B^{-1}C_1,\ e_t = B^{-1}\varepsilon_t$$

So we can rewrite Equation (4.37) as:

$$x_t = \mu + \sum_{i=0}^{\infty} A_1^i B^{-1} \varepsilon_{t-i} \tag{4.40}$$

So now we have structural shocks ε_t*'s* instead of reduced form residuals as explanatory variables for the endogenous variables. The impulse response parameters are 'hidden' in the term $\sum_{i=0}^{\infty} A_1^i B^{-1}$. Furthermore, it is important to remember that obtaining structural or independent shocks from the reduced form is not possible unless the system is identified. One of the popular solutions is to restrict the *B* matrix, say by using the Cholesky decomposition or other methods of identification. In any case, once the identification problem is resolved the standard VAR tools such as the impulse response function, the error variance decomposition and the Granger-causality test can be undertaken.

To probe further Equation (4.40) to see how the individual impulse response functions look like, we need to convert the equation into a vector form. We will use the bivariate form again to illustrate this, and our starting point is the reduced form (see Equation (4.41)).

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[28] This implies that there is enough restrictions on the structural parameters so that the system is solvable (see Enders (1995, p. 323) for more detailed discussion on this).

$$\begin{bmatrix} y_t \\ m_t \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{m} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} e_{1t-i} \\ e_{2t-i} \end{bmatrix} \tag{4.41}$$

where $\bar{y}$ and $\bar{m}$ are the unconditional mean of y_t and m_t, i.e. if we

take the expectation of (4.40), we are left the unconditional mean vector $u = \begin{bmatrix} \bar{y} \\ \bar{m} \end{bmatrix}$

And using $e_t = B^{-1}\varepsilon_t$, *where B* is the normalized coefficient matrix of the endogenous

matrix , which is equal to $\begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix}$,

And its inverse[29] (i.e. B^{-1}) is $\dfrac{1}{1-b_{12}b_{21}} \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}$

So in terms of the structural shocks, (4.41) becomes

$$\begin{bmatrix} y_t \\ m \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{m} \end{bmatrix} + \left(\frac{1}{1-b_{12}b_{21}}\right) \sum_{i=0}^{\infty} \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}^i \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{mt} \end{bmatrix} \tag{4.42}$$

To simplify the notation, we create a 2 x 2 matrix $\phi_i = \left(\dfrac{A_1^i}{1-b_{12}b_{21}}\right) \begin{bmatrix} 1 & -b_{12} \\ -b_{21} & 1 \end{bmatrix}$

Equation (4.40) can then be rewritten as

$$\begin{bmatrix} y_t \\ m \end{bmatrix} = \begin{bmatrix} \bar{y} \\ \bar{m} \end{bmatrix} + \sum_{i=0}^{\infty} \begin{bmatrix} \phi_{11}(i) & \phi_{12}(i) \\ \phi_{21}(i) & \phi_{22}(i) \end{bmatrix} \begin{bmatrix} \varepsilon_{yt-i} \\ \varepsilon_{mt-i} \end{bmatrix} \tag{4.43}$$

And in a more concise form,

$$x_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i} \tag{4.44}$$

The four terms, $\phi_{11}(i)$, $\phi_{12}(i)$; $\phi_{21}(i)$ and $\phi_{22}(i)$ are the impulse response functions and represent the responses of the endogenous variables to the two structural shocks: ε_{yt} and ε_{mt}. To interpret these, $\phi_{11}(0)$ is the impact response of output (y_t) to its own shock and $\phi_{21}(2)$ is the impulse response of money (m_t) due to output shock in the second period. These impulse responses can be added period by period and if we carry on to infinity we get the long-run multipliers—provided the variable is stationary. If the variable is not

[29] The *ijth* element of an inverse of a matrix (say B) $= \dfrac{|C_{ji}|}{|B|}$ (see Greene, 1993, p. 25)

stationary, i.e. has a unit root, then the cumulative sum of the impulse responses will keep increasing.

It is important to note here that the way the variables are ordered could affect the numerical values of the impulse responses. This is more pronounced if the correlation between the variables concerned is high. Consequently this is one drawback of the VAR framework, i.e. the responses are not unique—they depend on the ordering of the variables.

4.8 Forecast error variance decomposition:

This is basically an approach to measure how much of a variable's forecast error variance is due to each particular shock in the VAR system—including its own shock. As implied in the name of this technique, the essential idea revolves around the forecast error. This is given as:

$$e_{t+1} = x_{t+1} - E_t x_{t+1} \tag{4.45}$$

This is the one-step ahead forecast error of the reduced form VAR where $E_t x_{t+1} = A_0 + A_1 x_t$ is the variable forecast and x_{t+1} is the realized value of the variable. And as explained in the impulse response function section, we can interchange the reduce form residual with the structural disturbance term. Furthermore, since the structural VAR can be represented as a vector moving average (VMA) form, we can use the format of Equation (4.44)—but this time generalizing the period to *(t+n)* in order to get the appropriate forecast expression:

$$x_{t+n} = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t+n-i} \tag{4.46}$$

And the corresponding forecast error is

$$x_{t+n} - E_t x_{t+n} = \sum_{i=0}^{n-1} \phi_i \varepsilon_{t+n-i} \tag{4.47}$$

Given the forecast error expression above, all we need to do now is to determine its variance but more importantly, how much of this variance is due to the different structural shocks in the system. This decomposition is not very obvious from Equation (4.47) so to make this more apparent, we will resort to our bivariate example of output and money again and try to explain this issue in a more explicit manner. We will use money variable as an example. The forecast error is given below

$$m_{t+n} - E_t m_{t+n} = \phi_{21}(0)\varepsilon_{yt+n} + \phi_{21}(1)\varepsilon_{yt+n-1} + ... + \phi_{21}(n-1)\varepsilon_{yt+1} + \phi_{22}(0)\varepsilon_{mt+n} + \phi_{22}(1)\varepsilon_{mt+n-1} + ... + \phi_{22}(n-1)\varepsilon_{mt+1} \quad (4.48)$$

Now let us suppose the forecast error variance of money is $\sigma_m(n)^2$, then

$$\sigma_m(n)^2 = \sigma_y^2[\phi_{21}(0)^2 + \phi_{21}(1)^2 + ... + \phi_{21}(n-1)^2] + \sigma_m^2[\phi_{22}(0)^2 + \phi_{22}(1)^2 + ... + \phi_{22}(n-1)^2] \quad (4.49)$$

So the proportion of money variance due to output shock is

$$\frac{\sigma_y^2[\phi_{21}(0)^2 + \phi_{21}(1)^2 + ... + \phi_{21}(n-1)^2]}{\sigma_m(n)^2} \quad (4.50)$$

And the proportion due to the money shock

$$\frac{\sigma_m^2[\phi_{22}(0)^2 + \phi_{22}(1)^2 + ... + \phi_{22}(n-1)^2]}{\sigma_m(n)^2} \quad (4.51)$$

One implication of this decomposition is that if the proportion of the money forecast error variance due to output shock is almost zero, then money supply can be considered as exogenous. On the other hand, if output shock explains all the forecast error variance of money, then money would be considered as entirely endogenous.

As in the case of the impulse response function, the ordering of the variables is important here as well. That is, when the ordering is changed, the proportions may change as well—and the difference will be more pronounced when the correlations between the variables are strong, which is often the case in time series data.

4.9 Granger-causality test

Although causality may seem a simple word with a fairly straightforward meaning, like gravity causes things to fall down instead of flying up, or the storm causes the cancellation of flight to Kiribati, in empirical analysis this may be not be so straightforward as it seems. In the words of Pearl (1998): *It is an embarrassing yet inescapable fact that probability theory, the official mathematical language of many empirical sciences, does not permit us to express sentences such as: Mud does not cause rain; all we can say is that the two events are mutually correlated, or dependent—meaning that if we find one, we can expect to encounter the other.* In other words, probability theory can only give measures of correlations or independence but not of causal effect. In view of this, it is important that the meaning or explanation of Granger-causality as used in this study is clearly explained.

Basically Granger-causality is related to the idea that if past values of one variable (say money supply) can explain well the present value of another variable (say output), then we say: money Granger-causes output[30]. In terms of empirical analysis, money Granger-causes output if the coefficients of the lags of money variable are significantly different from zero. Another way of saying this is: money does not Granger-cause output if and only if all the coefficients of the lags of money are equal to zero. Let us illustrate this idea using the bivariate example of money and output again.

$$\begin{aligned} y_t &= \alpha_{10} + \alpha_{11} y_{t-1} + \alpha_{12} y_{t-2} + \ldots.. + \beta_{11} m_{t-1} + \beta_{12} m_{t-2} + \ldots. + e_{yt} \\ m_t &= \alpha_{20} + \alpha_{21} y_{t-1} + \alpha_{22} y_{t-2} + \ldots. + \beta_{21} m_{t-1} + \beta_{22} m_{t-2} + \ldots. + e_{mt} \end{aligned} \tag{4.52}$$

So to test the null hypothesis that money does not Granger-cause output, we need to test the following restriction: $\beta_{11} = \beta_{12} = \beta_{13} = \ldots\ldots\ldots.. = 0$, using the standard F-test[31]. If we reject the null hypothesis, then we can say that there is evidence, based on the available data, that money Granger-causes output.

Now if we compare the concept of exogeneity with Granger-causality there is some similarity but in the exogeneity case the contemporaneous values of the variables are included also so the necessary condition for exogeneity[32] is 'stronger' than that of Granger-causality.

Another important application of the Granger-causality approach is to test whether a particular variable should be included in the VAR model or not. This will involve restricting the coefficients of a particular variable and its lags to zero in all the equations within a multivariate model and applying the likelihood ratio test[33]. The degrees of freedom here is equal to the total number of restrictions (i.e. the total number of coefficients that are

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[30] The details of Granger-causality test can be seen in Granger (1969).
[31] See Enders (1995, p. 315) for more discussion on this.
[32] Different definitions of 'exogeneity' is given in Engle et al. (1983). Another interesting paper on exogeneity and policy analysis is provided by Ericsson et al (1998). And Perez (2002) empirical study of on 'superexogeneity' between the federal funds rate and real output provides another interesting dimension of exogeneity.
[33] The likelihood ratio test statistic formula is given in Equation (4.26).

equated to zero in the entire model). Because the lag of a particular variable is set to zero in other equations within the model (i.e. there is cross-equation restriction), this test is sometimes known as block-causality test. Note also that the application of the cross-equation restriction necessitates the use of the likelihood ratio test rather than the more straightforward F-test. This is the test that is used in this study.

4.10 Summary

This chapter has briefly outlined some econometric issues and tool kits that are commonly used in the VAR application. The intended use and advantages of these as well as their limitations are also indicated. For example, the unit root tests are shown to have low power and likewise the impulse responses and the variance decompositions are known to depend on the ordering of the variables, i.e. not unique. And the Granger-causality test is basically an inter-temporal correlation device that may lack the 'richer' causal meaning that many researchers prefer[34]. But despite the shortcomings listed, the tools have been used by many empirical researchers and have provided useful information and insight of the interrelationships between variables. As noted by Stock and Watson (2001), *"Developing and melding good theory and institutional detail with flexible statistical methods like VARs should keep macroeconomists busy well into the new century"*.

[34] According to Cooley and LeRoy (1985), the concept of causality or exogeneity that is tested by the Granger and Sims tests is not closely related to the causality of the Cowles Commission economists (which is more structural in nature).

Chapter 5

METHODOLOGY and MODELING STRATEGY

5.1 Introduction

In order to evaluate and understand monetary transmission mechanisms, the approach considered in this study is to subdivide the analysis into three main sections. The first section focuses on the monetary neutrality aspect; the second will examine, evaluate and compare the different monetary transmission mechanisms, and the last section will compare the transmission mechanisms in New Zealand and Australia. However as in most empirical studies, these analyses will be preceded by visual examination of the time plots of the series and some preliminary tests on the nature and properties of the data.

The first analysis on monetary neutrality involves testing a classical proposition that has caused so many debates and controversy between different macroeconomic schools of thought[1]. This test is relevant to the current study because it is meant to provide empirical evidence of the impact of money on real output[2]. The fundamental question here is: *Does money affect real output?* This first analysis can be considered as setting the scene for the next analysis which is basically an attempt to answer the question: *How does money affect real output?* In this second analysis the focus is more on the evaluation and understanding of the various monetary transmission models that have been proposed. This will involve examining and comparing the impulse responses, variance decompositions and Granger-causalities across different transmission models. Summary measures reflecting the total responsiveness/effectiveness of each model will also be formulated and used. The last analysis is a comparative analysis between New Zealand and Australia to see whether there is any significant difference in the way monetary impulses are being transmitted to real output in the two countries. This is particularly important because of the divergence in output paths of the two countries in the mid 1980s when New Zealand started its economic reform policies. The question here is: *Can the monetary transmission mechanism explain this divergence in output paths of the two countries*?

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[1] Discussed in detail in Chapter 2.

[2] This is seen necessary because despite the accumulated empirical results there is still no definite answer to the question as whether money affects output (Cheung and Fujii, 1999).

Vector autoregression (VAR) is the main analysis framework for this study[3], however other simpler statistical techniques, like single equation regressions and correlation analysis are also utilized in examining the more straightforward relationships—for instance, when carrying out tests for unit root or structural break or for stability. Neutrality and superneutrality tests, as well as the evaluation of different transmission mechanisms, rely heavily on the standard VAR tools such as the impulse response function (IRF), forecast error variance decomposition (FEVD) technique[4] and the multivariate Granger-causality test and consequently these are the main analytical tools in this study. These tests and the VAR tools are carried out automatically by many computer packages (e.g. WinRATS, Eviews and Microfit); however because of their crucial role in this study their derivations and theoretical basis are provided in Chapter 4. Because the VAR systems are generally overparameterized the results of the tests and the responses/decompositions observed are more informative than the regression coefficients[5] themselves—in fact in most empirical studies these coefficients are never reported (see, for example, Stock and Watson, 2001). In this study both Microfit and Eviews will be used in estimating and testing the models however in order to be more flexible in manipulating the numerical results in terms of normalization, or in constructing new series, or in drawing different graphs, the results will be transferred to Excel spreadsheet. Microfit and Eviews have tabulations and graphical capabilities, but it is not quite easy to change or manipulate the outputs in these programs hence the use of Excel spreadsheet.

With respect to the monetary transmission issue, this study will introduce two ways this could be viewed and investigated. The concept is borrowed from physics and consists of two transmission modes—one is called the 'serial transmission' mode and the other is the 'parallel' transmission mode. This concept is fairly novel to the monetary transmission literature but is considered useful here because it provides a systematic way of examining and evaluating the different monetary transmission models. At least according to the

[3] Other monetary transmission studies that have used the VAR framework include that of Bean et al. (2002); Faust et al. (2002); Favara and Giordani (2002); Hubrich and Vlaar (2000); Kamas and Joyce (1993), among others.

[4] In the words of Keating (1992), *"Impulse response functions and variance decompositions, the hallmark of VAR analysis, illustrate the dynamic characteristics of empirical models"*.

[5] This is unlike the structural equation systems where the coefficients and their statistical significance are often reported--these coefficient are sometimes referred to as 'deep structural' parameters (see, for example, Summers (1991)).

prevailing theoretical transmission models the monetary impulse seems to be transmitted from one variable to another[6], i.e. along a serial path, somewhat like the serial transmission in electrical physics. In contrast, most empirical VAR studies seem to concentrate only on the final effects of monetary policy, say on output or inflation, without actually tracing the 'full' path of the monetary transmission process. This 'short-cut' approach will be called the 'direct transmission' mode in this study and will be discussed in more detail in Section 5.5.2 below.

5.1 VAR (and VEC) framework

Before we go on to the details of how to carry out the neutrality and monetary transmission analyses, it is useful to start off with the theoretical model or framework that underlies such analyses—the vector autoregression framework. The exposition of this framework will be based on a bivariate model for the simple reason that using a single equation with each variable in it representing vectors could be confusing given the existence of many single equation models in economics. Also the bivariate model is naturally the smallest multivariate version of the VAR system and therefore is concise and tractable. More importantly, the structure and features of the bivariate model are generally the same with those of the higher order (or larger) VARs.

The VAR model has generally three representations—a 'structural' (SF) form, a 'reduced' form (RF), and an infinite moving average (VMA) representation. This latter form is only possible if the coefficient matrix of the endogenous variables in the SF has full rank or has a determinant, i.e., invertible[7]. These three forms are very important because they provide a concise but comprehensive description of what constitutes a VAR system. In fact it is a very rich framework allowing dynamic relationships and feedback mechanisms and with appropriate restrictions, can simulate different economic theories. In the words of Stock and Watson (2001), *"In data description and forecasting, VARs have proven to be powerful and reliable tools that are now, rightly, in everyday use"*. Although some criticisms[8] have been made regarding the lack of economic structure, there is actually some means within the

[6] This systematic approach is somewhat captured in Kuttner and Mosser (2002) who said: Monetary transmission can be thought of as encompassing the various ways in which monetary shocks propagate through the economy. But monetary policy is more than just a source of shocks: the systematic response of policy to macroeconomic conditions also affects the propagation of monetary (and other) shocks.

[7] Useful matrix algebra can be cited in the first chapter of Greene (1993).

[8] See, for example, Cooley and LeRoy (1985), Rudebusch (1998), among others.

framework that provides for contemporaneous relationships to be made—hence the name 'structural' VAR[9]. The three forms of the VAR are given below.

Structural VAR (SF):

$$\Delta y_t = \lambda_{ym} \Delta m_t + \sum_{j=1}^{p} \alpha_{jyy} \Delta y_{t-j} + \sum_{j=1}^{p} \alpha_{jym} \Delta m_{t-j} + \varepsilon_t^y \tag{5.1}$$

$$\Delta m_t = \lambda_{my} \Delta y_t + \sum_{j=1}^{p} \alpha_{jmy} \Delta y_{t-j} + \sum_{j=1}^{p} \alpha_{jmm} \Delta m_{t-j} + \varepsilon_t^m \tag{5.2}$$

Reduced (or standard) VAR (RF):

$$\Delta y_t = \sum_{j=1}^{p} \Phi_j \Delta y_{t-j} + \sum_{j=1}^{p} \Phi_j \Delta m_{t-j} + e_t^y \tag{5.3}$$

$$\Delta m_t = \sum_{j=1}^{p} \Phi_j \Delta y_{t-j} + \sum_{j=1}^{p} \Phi_j \Delta m_{t-j} + e_t^m \tag{5.4}$$

Vector Moving Average (VMA):

$$\Delta y_t = u_y + \sum_{i=0}^{p} \varphi_{yy}(i)\, e_{t-i}^y + \sum_{i=0}^{p} \varphi_{ym}(i) e_{t-i}^m \tag{5.5}$$

$$\Delta m_t = u_m + \sum_{i=0}^{p} \varphi_{my}(i)\, e_{t-i}^y + \sum_{i=0}^{p} \varphi_{mm}(i) e_{t-i}^m \tag{5.6}$$

Notes: The variables y_t and m_t can be in first-difference or in levels.
There is no cointegration, otherwise the error-correction should be included.
The disturbances (or residuals) are serially uncorrelated and homoscedastic, however the RF residuals may be cross-correlated, i.e. var-cov matrix Σ_e is non-diagonal, but the SF residuals are often assumed to be independent, i.e. the var-cov matrix Σ_ε is diagonal.

To briefly explain the three forms of the model, the SF, as mentioned above, is meant to put some structure to the system, i.e., the λ_{ym} *or* λ_{my} parameters, for instance, are the numerical measures of the contemporaneous relationships between the two variables[10]. In the derivation of the orthogonal shocks, one of these parameters will be restricted in order to identify the structural model. The RF, on the other hand, is useful for estimation purposes, i.e., because of the contemporaneous relationship in the SF form, the system

[9] As pointed out by Keating (1992), *"In contrast to the atheoretical VAR models developed by Sims (1980), the structural approach yields impulse responses and variance decompositions that are derived using parameters from an explicit economic model".*

[10] In the Cowles Commission approach, there are many of these structural parameters but in the estimation process most are restricted to zero hence the introduction of the term 'incredible restrictions' by Sims (1980).

cannot be directly estimated, hence the need to use the RF which is estimable. It should be pointed out however that the error terms (e_t) of the RF form may be cross correlated in which case some restrictions is needed (as is suggested above) in order to get independent or orthogonalised shocks. This process is known in the literature as the 'identification' problem and there are several approaches[11] but the most common method is the Cholesky decomposition[12]— this identification scheme will be used in this study.

There are two main reasons for using the Cholesky decomposition. The first reason is that the serial ordering of the variables in the theoretical transmission models seems to suggest that the variables have been more or less arranged according to their degree of exogeneity or endogeneity. For instance, the first variable is the money supply and this is supposed to be the start of the monetary transmission process, i.e. this would be the most exogenous variable. The last variable, real output, would be the most endogenous because it is assumed to be affected by all other variables. The Cholesky decomposition provides this kind of recursive setup. Another reason is that the objective of this study is to evaluate and compare the performance of the different transmission models, i.e. not necessarily to identify the most appropriate shock, and so any identification scheme would suit the purpose of this study—as long as it is applied consistently. The use of the Cholesky decomposition is also inspired from other studies that find qualitatively similar effects of monetary policy across a large subset of identification schemes (see, for example, Morsink and Bayoumi (2001)).

The moving average form (VMA) is a fairly important form because this shows the direct relationship between the endogenous variables and the disturbances (shocks)[13]. For instance, the impulse responses and the forecast variance decompositions that will be examined and evaluated in this study all emanate from this form. The four impulse response functions of the VMA are represented by $\varphi_{ym}, \varphi_{yy}, \varphi_{my}, and\ \varphi_{mm}$. These are the critical elements of the VAR framework because they constitute the main analytical tools of the system. As Runkle (1987) noted, *"Although VAR estimation is based on the AR*

[11] List of the approaches is given in Enders (1995, p. 227) and in Amisano and Giannini (1997).
[12] Known also as the 'recursive' identification scheme.
[13] In the words of King and Watson (1997), *"What is required is the model's final form showing the dynamic response of the variables to underlying structural shocks"*.

representation, most interpretations of VAR's are based on the vector moving average (VMA) representation".

The VEC framework is essentially the same as the VAR except now we add the error correction term (Πx_{t-1}) on the right hand side. This topic is discussed in more detail in Chapter 4, but it may be useful just to show the link here with the VAR.

(i) VAR

$$x_t = A_0 + \sum_{i=1}^{k} A_i x_{t-i} + \varepsilon_t \tag{5.7}$$

(ii) VEC

$$\Delta x_t = A_0 + \sum_{i=1}^{k-1} A_i \Delta x_{t-i} + \Pi x_{t-1} + \varepsilon_t \tag{5.8}$$

where x_t = vector of endogenous variables

A_0 = vector of constants

A_i = coefficient vector of lagged variables

$\Pi = \alpha\beta'$ where β is the matrix of cointegrating parameters and α is matrix of 'speed of adjustment' parameters

ε_t = is an independently and identically distributed vector with zero mean and var-cov matrix Σ_ε

So when there is cointegration among the variables, the VEC approach is used, otherwise the traditional VAR is used. This implies that whereas the traditional VAR can incorporate variables in levels or in first-difference, the VEC models are always in first-difference. The essential criteria for the VEC analysis therefore are that the variables must be integrated of the same order, and cointegrated.

5.3 Preliminary data investigation

As in most time-series analysis, it is always important to examine the properties or characteristics of the data. This preliminary investigation will start off with visual examination of the time plots of the various series to check for distinct and important characteristics such as outliers, structural breaks, seasonality, trends, and generally to get a 'feel' of the 'raw' data. Although this could be considered as subjective in the sense that no rigorous formal analysis[14] is involved, this is a vital starting point for most time series analysis. As pointed out by Hair et al. (1998, p. 39):

> The tasks involved in examining your data may seem mundane and inconsequential but they are an essential part of any multivariate analysis. .... By examining the data before the application of a multivariate technique, the researcher gains several critical insights into the characteristics of the data.

Enders (1995) and Frances (1998), among others, also highlighted the importance of this visual analysis as a starting point for time series studies. After visual examination, more 'formal' tests will be performed on the data, such as tests for unit roots, structural breaks, cointegration, and so forth. These characteristics are very important because they determine the way the analysis is to proceed and to some extent, the way the interpretations or conclusions are drawn. For instance, the impulse response function of nonstationary time series is very different to that of the stationary series and consequently what is applicable to stationary series may not be appropriate to nonstationary series[15]. Likewise, most unit root tests are biased towards nonrejection of unit root hypothesis[16] when the series has structural breaks –hence modifications are necessary to the unit root tests to take into account the structural breaks, such as that of Perron's test for structural break. In fact, results and conclusions from some studies in the past have been considered invalid because they did not take into account the nonstationarity character of the data series.

The more 'formal' tests include unit-root tests, Perron structural break test, Johansen cointegration test, and so forth. As part of the overall strategy to get robust results and conclusions, three unit root tests will be performed in this study—the augmented Dickey-Fuller (ADF) test, the Phillips-Perron (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests[17]. The use of several tests is sometimes known as 'confirmatory' analysis however it is useful to keep in mind that all these tests have low power against near-unit root alternatives[18]. The intention here, however, is not to get more 'power' by performing several tests, but rather to get more empirical evidence or broader confirmation of the results. As pointed out by Serletis and Koustas (1998), they used four alternative unit root

[14] Often refers to some form of mathematical analysis.
[15] This is explained in more detail under the 'Nonstationary' section in Chapter 4.
[16] See, for example, Enders (1995) and Maddala and Kim (1998).
[17] These are described in sub-Chapter 4.2.
[18] Several alternative unit root tests are discussed in Maddala and Kim (1998).

procedures[19] in order *"to deal with the anomalies that arise when the data are not very informative about whether or not there is a unit root"*.

Seasonal unit root tests will be applied only to series that exhibit a distinct seasonal pattern and are not stationary upon first differencing. This is important because to be able to use the standard distributions and inferential statistics, we need to use stationary variables. In other words, assuming the series has a seasonal unit root, we then need to difference it properly in order to obtain stationary representation—as opposed to the traditional method of taking first-difference straightaway to achieve stationarity.

For the structural break test, this will be carried out only on the real GDP series[20]. Perron (1989) test will be used here and as to the breakpoint, this will be exogenously provided. The reason why the break point is exogenously provided in this study is because the structural break seems to be quite obvious from the graph.

With the completion of the formal tests on the properties of the data series the next task is to formulate more specific modelling strategies. For instance, in terms of the long run neutrality test, one needs the variables, in particular the money supply, to be integrated otherwise the 'permanent' change required in Fish and Seater LRD formula cannot be obtained. Likewise, for superneutrality test, the money supply should have a higher order of integration than that of real output otherwise the inflation rate may have to be used instead of the money growth rate[21]. And in the case where the variables are cointegrated, the vector error correction (VEC) approach may have to be used instead of the standard VAR method.

The question as whether to use data in level or in first-difference, or more generally whether the data needs to be adjusted or not before the analysis, is still an unresolved issue[22]. In this study the intention is to apply minimal adjustment to the raw data. However if the data series has a unit root then its first-difference will be used. The data will not be deseasonalised but in case the responses exhibit erratic behaviour or the convergence of the

[19] The ADF, PP, KPSS and the Augmented Weighted Symmetric (WS) tests.
[20] As is done in Sanyal and Ward (1995).
[21] This presumes inflation rate is directly related to money growth rate.
[22] On this, Enders (1995, p.301) said, *"The issue of whether the variables in a VAR need to be stationary exists"*, and then went on to say that *"Sims (1980) and others, such as Doan (1992), recommend against differencing even if the variables contain a unit root"*.

long run responses seem to be a problem due to seasonal effects, then seasonal dummies may be added to the model. In other words, the underlying philosophy in this study is to try to capture and understand how the actual data interact with each other—hence the need to apply minimum transformation necessary for the analysis to be undertaken. Even the usual procedure of taking natural logarithms will not be undertaken unless the data exhibit distinct exponential growth pattern or the numbers are so large and cumbersome to work with in which case a more compact logarithmic form would be a more convenient form to use. In any case the transformation is simply a monotonic transformation so the basic relationships remain unchanged, except the loss of the elasticity (or growth rate) coefficients that are generally available when logarithmic data are used.

The next section will explain the long-run neutrality test framework as formulated by Fish and Seater (1993). This is a fairly important development in econometric empirical work because before then reduced form econometric tests were considered not robust after Lucas (1972) and Sargent (1991) provided examples in which it is impossible to test long run neutrality using reduced form methods[23].

5.4 Neutrality and superneutrality tests

5.4.1 Neutrality tests

The LRD test framework of Fish and Seater (1993) will be used in this study to test monetary neutrality and other important classical propositions, such as Fisher's relationship, the short run Phillips curve, the Monetarist's long standing claim that inflation is a monetary phenomena, etc. As explained above, before the test is undertaken, it is important that the order of integration of the variables is determined. Johansen cointegration test will also be carried out to make sure that the model is well specified, i.e. if there is cointegration, the VEC format will be used otherwise the standard VAR will be used.

As to the actual variables that will be used in the neutrality test, monetary aggregates (M1 and M3) and real output (GDPR) will be used as in most other neutrality studies[24]. Nominal

[23] As cited in King and Watson (1997).

[24] Such as Boschen and Otrok(1994), Fish and Seater (1993), King and Watson (1997), Serletis and

output will also be used but this time the neutrality hypothesis requires that LRD = 1, i.e. the increase in money supply is fully reflected on a one-to-one basis in nominal output. Other variables include the nominal interest rate and the inflation rate (CPI).

In addition to the computation of the point estimates of the LRD test statistic, a confidence band of 68 per cent will be estimated as well. This confidence band will be calculated from the standard errors of the two long run multipliers[25] provided by Eviews. The computation of both the LRD test statistic and its confidence band will be carried out using Excel spreadsheet.

A bivariate VAR is used not only because it is tractable but also because the main aim of this study, in particular the focus of the neutrality and superneutrality tests, is basically to study the interrelationship between money and real output, i.e. relationship between two variables. Potentially this may give an omitted variable bias result as King and Watson (1997) warned against but so far there has been no documented empirical evidence of this bias. On the contrary, Bullard (1999) refers to Boschen and Mills (1995) result as providing *"the best available evidence that omitted variable did not contaminate the previous results on this question"*. Nevertheless in order to see first-hand whether there is indication of omitted variable bias, a trivariate VAR will also be estimated in this study and its responses and time-lags[26] will be compared to the bivariate model results (this is further elaborated in Section 5.4.3 below).

5.4.2 Superneutrality test

The proposition of superneutrality (as mentioned earlier) is very similar to the neutrality case except now the growth rate of money is used. Empirical evidence on this is quite mixed but as noted by Bullard (1999), *"this is not surprising given there are theoretical models that support superneutrality and there are others which do not"*. For instance, Rapach (1999) reports, *"long-run monetary superneutrality is rejected for all countries, as*

Koustas (1998), among others.

[25] Eviews provides one standard error (68%) for the long run multipliers it computes. Buckle et al. (2002) in their study on New Zealand business cycle use the 68% confidence band as well.

[26] Time-lag and lag-period will often be used to denote the period when the maximum or peak response of a variable to an exogenous shock is observed. For instance, when output peak response after a monetary shock occurs in the 4th quarter, we say that output has a lag-period (or time-lag) of four quarters.

the results indicate that a permanent increase in inflation lowers the long-run real interest rate in each of the 14 countries". King and Watson (1997), on the other hand, argued, "*that conclusions about the long-run Fisher effect and the superneutrality of money are not robust to the particular identifying assumption"*.

One likely problem with superneutrality test is that money aggregates and real output are usually integrated of order one—meaning that they become stationary upon first differencing. This means that money growth rate will be stationary or has no unit-root in which case the Fish and Seater LRD test may not be appropriate. That is, we want money aggregate to be integrated of order two—at least it should be one order above the integration order of real output. It is for this reason that superneutrality tests in the past have been undertaken using inflation rate instead of money growth rate (see, for example, Rapach, 1999; King and Watson, 1997). In this study inflation rate variable will be used if money supply turns out to have order of integration of one.

5.4.3 Robustness test (a trivariate VAR)

Although the estimation of this model is meant as some form of robustness check on the bivariate model results, it is in itself interesting in that the interactions and feedbacks are getting more 'richer' with more variables involved and more sources of structural shocks. Ideally one would like to include more relevant variables but this would complicate the process if it becomes too large—besides, it would defeat the whole purpose of the VAR analysis which is to generally work with smaller number of variables. This is in contrast to the traditional Cowles Commission structural equations approach which prompted Sims (1980) to label the identification process involved as 'incredible'[27].

Another interesting aspect of having more variables in a VAR model is the possibility of getting some cointegration relationships, in which case the analysis would be slightly different. In particular we would have the option of studying both the short run adjustments[28] and the long run responses of the variables—something that has traditionally been difficult to obtain given the nonstationarity of the data[29].

[27] Referring to the large number of restrictions needed to identify the model.
[28] Represented by the first differences.
[29] According to the classical regression analysis, variables should be stationary (see Thomas, 1993; p. 151).

The three variables for the trivariate VAR model will be: real GDP, inflation rate and money aggregate M1. Apart from the important economic relationships among these variables, these have been estimated in the bivariate models and so it is only logical that they are reestimated in a trivariate format for crosschecking and comparison purposes.

After testing monetary neutrality and other important classical bivariate relationships, the next analysis is on the monetary transmission aspect.

5.5 Monetary transmission mechanisms

5.5.1 Overview

This is considered a natural and logical extension of the monetary neutrality tests because assuming money had been found to be non-neutral, then the next step would be to investigate how this non-neutrality arises, i.e. what mechanism is responsible for transmitting the monetary effect to real output. This has been a long-standing issue both from the theoretical and empirical point of views. The empirical analysis in this study is intended to supplement the existing evidence on the issue. The questions that this section addresses are: *How is the monetary impulse being transmitted? What is the most plausible transmission channel? What are the magnitudes of the variable's responses to different shocks? How long it takes the monetary impulse to reach the intermediate and the final policy targets?* These questions are obviously important to economists as well as to policy makers.

In the monetary transmission literature there are several possible channels in which the monetary impulse can be transmitted from the monetary policy instrument to real output (or inflation) as discussed in Chapter 2. Kuttner and Mosser (2002) identify six channels: through interest rate; exchange rate; wealth; other asset prices; broad and narrow credit. This study will investigate only four channels which Mishkin (1995) listed and which are essentially the subset of the six channels mentioned, namely: interest rate channel; exchange rate channel; 'other-asset price effects' channel, and the credit channel. The credit channel will be split into two: one incorporating business investment and the other household consumption expenditure. So in total there are five transmission channels.

The selection of the variables to be included in each model is based on the transmission theory underlying each model[30]. For instance, in the exchange rate transmission model, the theory posits monetary impulse as starting from money supply, then moves to interest rate, then to exchange rate, exports, and finally to real output. Accordingly there are five variables, viz., money supply, interest rate, exchange rate, exports and real GDP that will be used in the analysis of the exchange rate model. In the case where a particular variable or construct, like the Tobin's '*q*' is very difficult to obtain, then the model will be estimated without that construct. This should not affect the analysis substantially given that the major components of the models (like monetary aggregate, interest rate, equity price, credit, etc.) are available —besides, Tobin's '*q*' empirical performance has been generally unsatisfactory (see, for example, Chirinko (1993) or Bernanke and Gertler (1995)).

As mentioned in the overview of this chapter, there will be two modes of transmission that will be considered in this study and these will be discussed below.

5.5.2 Serial and parallel transmission modes

The two transmission modes that will be considered in this study are: the '*serial*' and '*parallel*' transmissions. This is a basic concept in electrical physics[31] but one that has not been introduced in the monetary transmission literature[32]. The attractiveness and the advantage of this approach is that it gives more logical structure and consistency in the way we evaluate and compare different transmission mechanisms. This is not to say that we can measure economic phenomena exactly like scientific experiments but at least the systematic approach and the underlying philosophy of the transmission in physics could provide an objective and meaningful basis for measuring and comparing alternative transmission models.

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[30] Focusing on the important variables is also suggested by Kake (2000) who said: *A more promising strategy is to follow an indirect approach that focuses on the so-called transmission variables which are supposed to play a crucial role in the transmission of a monetary policy.*

[31] The serial and parallel circuits can be cited in standard physics text books, see for example, Hudson and Nelson (1982, p. 592-594).

[32] Angeloni et al. (2002) study uses the term 'sequential' to measure the dominance of the interest rate channel. Their approach however is different to the one intended for this study.

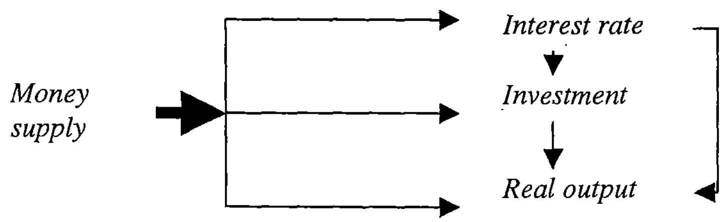
In essence the idea is that in a 'serial' transmission mode the monetary impulse (analogous to electricity impulse or current) moves from variable to variable in a serial fashion suggesting some kind of straight-line path. In the 'parallel' transmission approach, the monetary impulse is assumed to affect all the other variables at the same time, including real output. These concepts are illustrated below (the interest rate channel is used only to demonstrate the idea, otherwise this is applicable to other transmission channels as well).

(i) Serial transmission mode:

Money supply → *interest rate* → *investment* → *real output*

where a monetary shock starts in the monetary supply and subsequently gets transmitted to the interest rate, then to investment, and finally to real output—in a serial fashion

(ii) Parallel transmission mode:



where the monetary shock starts from the money supply and then simultaneously affect interest rate, investment and output.

From the illustration *(ii)* above we see that real output can be affected by several channels following a single monetary shock, at least conceptually. This is why this transmission mode is called the 'parallel' transmission mode. Unfortunately it is very difficult to trace out and quantify these channels separately, and this is why most VAR studies concentrate only on the initial shock and the 'final' response of output or inflation. In this study this popular 'short-cut' view of the transmission process will be referred to as the 'direct transmission' mode.

While it is easy to conceptualise how the monetary transmission could have taken place, the main problem now is how to empirically measure such transmission modes, i.e. the serial, parallel, and direct transmissions. This is one great challenge of this study and the next section will outline a procedure that this study will use in this aspect. It is useful at this early stage to say that the procedure is based mainly on the bivariate relationships and on the theoretical orderings of the variables as stipulated in each monetary transmission channel. Even the parallel transmission mode analysis is based on this approach but the only difference is that each transmission model is estimated with all its variables in 'one go'—as in most VAR studies.

5.5.3 Empirical representations of the serial and parallel modes

To represent the serial mode of transmission in an empirical context, a sequence of bivariate models will be estimated. In doing this, the source of the shock comes from only one variable with no other external influences—as when a current goes from resistor A to resistor B in a single wire. For instance, in the interest rate model we need to estimate three bivariate VAR models: the first is money supply and interest rate, the second is interest rate and investment, and the last is investment and real output. Once these bivariate models have been estimated then the bivariate responses, the variance decompositions, and the Granger-causal test statistics can be examined, evaluated and compared. These will provide the numerical values of the relative strength of the relationships on which the plausibility of the various theoretical models depend on. For instance, if we find that the money supply does not Granger-cause the interest rate but the interest rate does Granger-cause money supply, then this imply that the model is not empirically supported, i.e. it may be that the model needs to be revised taking into account this Granger-causal evidence. Likewise, the results from the impulse response and the variance decompositions will be examined and interpreted in the same manner.

As to the 'parallel' transmission mode the empirical representation is that of a standard VAR estimation with all the variables concerned included. For instance, for the exchange rate model, we will have a single VAR comprised of monetary aggregate, interest rate, exchange rate, exports and real output. This single VAR will be estimated and its bivariate relationships examined and evaluated as is done for the serial transmission mode. This same procedure will be carried out on other transmission models as well. What is important in both transmission modes is that the analysis will focus on the bivariate relationships and on the sequence of the variables as stipulated in each transmission model.

In the direct transmission approach, the analysis is generally the same as other empirical studies which basically involve looking at the response of output to monetary shock, or the decompositions of output due to the shocks of the money supply and other variables present in the model. Likewise, the Granger-causality test focuses mainly on output as the dependent variable. The difference therefore between this 'traditional' approach and the two approaches above is that the analysis in the latter goes from variable to variable with real output as the last variable in the transmission chain—hence the name 'serial' analysis.

In order to be consistent, a standard VAR will be used for all the transmission models—both in the serial and parallel mode approaches. Also the Cholesky decomposition will be used in the identification process on all the models.

5.5.4 Model performance measures

In order to compare one model with another, there is always a problem of choosing which measures or criteria to use. Obviously there are statistical tests of model adequacy (for example: AIC, SBC, maximized likelihood function, etc) or the normal t or F tests for the model parameters, however in this study the approach focuses on the magnitude of the responses, the lag-periods, the variance decompositions and the Granger-causality test results. For instance, if we find the responses in the interest rate model to be relatively larger than the responses observed in the exchange rate model, we would say that the data seems to fit the interest rate model better than the exchange rate model. Likewise, if the Granger-causality test results show more plausible results when the credit channel framework is used then we would say that the credit channel seems to model the data better than the other models. Obviously this means the point estimates will be extensively used here. The standard errors, on the other hand, will not be given much emphasis because the point estimates of the impulse responses are relatively small and the differences across the different models are even smaller. Besides, as Stock and Watson (2001) point out, *"One of the VAR limitations is that the standard methods of statistical inference (such as computing standard errors for impulse responses) may give misleading results if some of the variables are highly persistent"*. And on this Runkle (1987) says, *"The confidence intervals for the variance decomposition and impulse response functions are often so large that little useful reference can rely on them"*. In other words, there seems to be some consensus that the confidence intervals in the VAR system may not be very reliable. This problem may be exacerbated if the number of observations is limited.

But while it is easy enough to compare and discuss the responses and other statistical relationships among individual variables, as a group (i.e. as a complete transmission model), this is quite difficult. Ideally some summary measures are needed so that we can say transmission model A is more responsive that model B, or that model C has shorter lag-period than model D, etc. In this study some fairly simple and rather crude summary measures will be formulated for comparison purposes—otherwise it will be very difficult to compare the different transmission models.

With respect to the summary response of the models, the idea here is to develop a composite measure that is based on the largest (or peak) response of the relevant variables within each transmission model. For instance, suppose we are working with the interest rate channel, then we would examine the response of interest rate to monetary shock; the response of investment to interest rate shock; and finally the response of output to investment shock. And suppose we find that the peak responses are: 0.05 units (or 5 per cent) in the 4^{th} quarter, 0.15 units in the 5^{th} quarter and 0.20 units in the 3^{rd} quarter, respectively. So for this model the composite or summary measure of the responses would be: 0.05 x 0.15 x 0.20 = 0.0015 units (or 0.15 per cent). And for the total lags, this is more straightforward, i.e. we just add the lag-periods together, e.g. 4 + 5 + 3 = 12 quarters. For the variance decomposition summary measure, we would simply multiply the proportions together as in the response method. And for the Granger-causality summary measure, we would just add the individual *p*-values together and the smallest *p*-value total would be the most plausible model. Whether or not these composite or summary measures have any practical relevance remains to be seen but at least they provide some quantitative measure for comparing the relative responsiveness or effectiveness of the different monetary transmission models.

5.6 Comparative analysis between New Zealand and Australia

This is the last major section of the analysis and involves a comparative analysis between Australian and New Zealand monetary transmission mechanisms. The objective is to see if there is any significant difference in the monetary transmission mechanisms, especially in terms of the responses, variance decompositions, and the Granger-causal effects. These are important because they may reflect the unique structure and institutional setting of each country and which policy makers in each country could use to formulate relevant and appropriate macro polices.

The procedure for estimating and evaluating the VAR models for Australia will follow what has been suggested for New Zealand however there will be no separate bivariate model estimation this time, i.e. each transmission model will be estimated as a single large VAR as is suggested for the 'parallel' transmission approach. From these large VAR models the relevant bivariate relationships, in the form of impulse responses, variance decompositions and Granger-causal effects, will be 'teased' out and used in the analysis. In other words, there will be no 'serial' transmission analysis for Australia. This is basically because the 'parallel' transmission mode is the more 'realistic' setting given that in real life economies generally contain many variables and disturbances that are constantly interacting and influencing each other.

Finally, given the apparent divergence in the output paths of the two countries in the 1980s, a counterfactual analysis will be carried out to see the different or the 'what-if' scenarios. This will basically involve questions like: *if New Zealand had followed Australia's interest rate policy, how would its output turned out?* Alternatively we could say, *suppose Australia had followed New Zealand's monetary policy, how would its economy performed?* The counterfactual experiment will involve changing the interest rate of say New Zealand to follow that of Australia (and vice versa), especially in the 1985-90 period when the interest rates of the two countries seem to diverge from each other. After re-estimating the model, the magnitudes of the responses and other test statistics will be compared to the results emanating when actual data are used. The variables for this counterfactual experiment are monetary aggregate, interest rate, price and real output[33]. There will be cointegration test to see if there is any cointegration relationship—if there is, then the VEC model will be used, otherwise the standard VAR will be used. The number of lags will be set as to minimize the problem of serial correlation, heteroscedasticity, and stability.

[33] According to Runkle (1987) explaining the relationships between these four variables is one of the most important challenges in macroeconomics.

Chapter 6

MONETARY NEUTRALITY TESTS

6.1 Introduction

This chapter and Chapter 7 contain the empirical analysis. In this chapter the data properties are examined and the tests of monetary neutrality and superneutrality undertaken using the bivariate VAR models. In Chapter 7 the evaluation of the monetary transmission mechanisms is carried out. These two chapters constitute therefore a very crucial part of the study because the analysis and the results are meant to provide empirical evidence to the theories and the complex issues raised in the previous sections, but in particular to the role of money in influencing real output. Needless to say, whether or not the objectives are met, or whether the hypotheses stated in this study are rejected or not, depend critically on the results obtained from the subsequent set of analyses. As pointed out by Tintner (1952), *"It is one thing to develop the theoretical concept of the elasticity of demand, ... It is another thing to state that the estimated price elasticity of demand ...., on the average is -0.123"*. The following analysis takes on the same spirit with the aim of providing numerical measures that can be used for inference or surmising purposes[1]. The importance of the quantitative approach is also highlighted by Friedman (2000) when he said, *"One of the key areas of ongoing research work is the quantitative measurement of whatever transmission mechanism is at work"*.

Like most forecasting that is based on equations and estimated parameters, whether they are single equations or multiple equations, the forecast values (or impulse responses) are naturally the reflections of what have taken place or experienced in the past. In view of this, the responses that emanate after exogenous shocks (or unexpected changes) have taken place are useful not only as measures of the endogenous variables likely future paths, but also as records of what were the past relationships among the variables. This could provide some clues as to what policies were undertaken in the past but more importantly, the means of evaluating the effectiveness of such policies. For instance, several studies have noted the substantial decline in the US output and inflation volatility since the 1980s and have used

[1] As noted by Zellner (1984), *"One part of our knowledge is merely description of what we have observed; the more important part is generalization or induction"*.

VAR based and structural system responses to study and evaluate these declining phenomena[2].

6.2 PRELIMINARY DATA ANALYSIS

6.2.1 Data: Sources and Characteristics

The data for New Zealand is obtained from the Reserve Bank of New Zealand, Statistics New Zealand and from the Lincoln University DataStream database. In the case of Australia, the data is obtained from the DataStream database and from the internet webpages of the Australian Reserve Bank and the Australian Bureau of Statistics. The quarterly data start from 1977 and end in March 2002. Some data have been downloaded from the respective websites of the two institutions but others have been obtained after contacting the two institutions directly. The two institutions also provided useful information regarding the scope and compilation methods. However it is important at this early stage to say that having different data sources, different base years as well as different compilation methods could be a source of confusion when deciding which series to use. Moreover, when the series is disjointed, the question and problem of how to link the different portions arises. For instance, one series of real GDP figures stops in June quarter 2000, while another series starts from June quarter 1987. In the case of money aggregates series, similar problems arise and as one official of the Reserve Bank reported[3], *"A major problem we have with NZ money series is discontinuity in the surveys from which the numbers are generated. There are in fact 3 sets of monetary series. Each set comes from a different data collection framework".* In view of these differences and discontinuity in some series, it is important that caution is exercised when interpreting the results. However given that the general trend and rate of changes of the different portions of the series are quite similar, the analysis and the conclusions should be reasonably accurate and representative. The method by which the data are actually manipulated and joined together for the analysis is explained in the subsequent paragraphs.

Fig 6.2.1 shows graphs of the data (in level) that are used in the first part of the analysis— i.e. for the neutrality and superneutrality tests, and Fig 6.2.2 shows the rest of the data used

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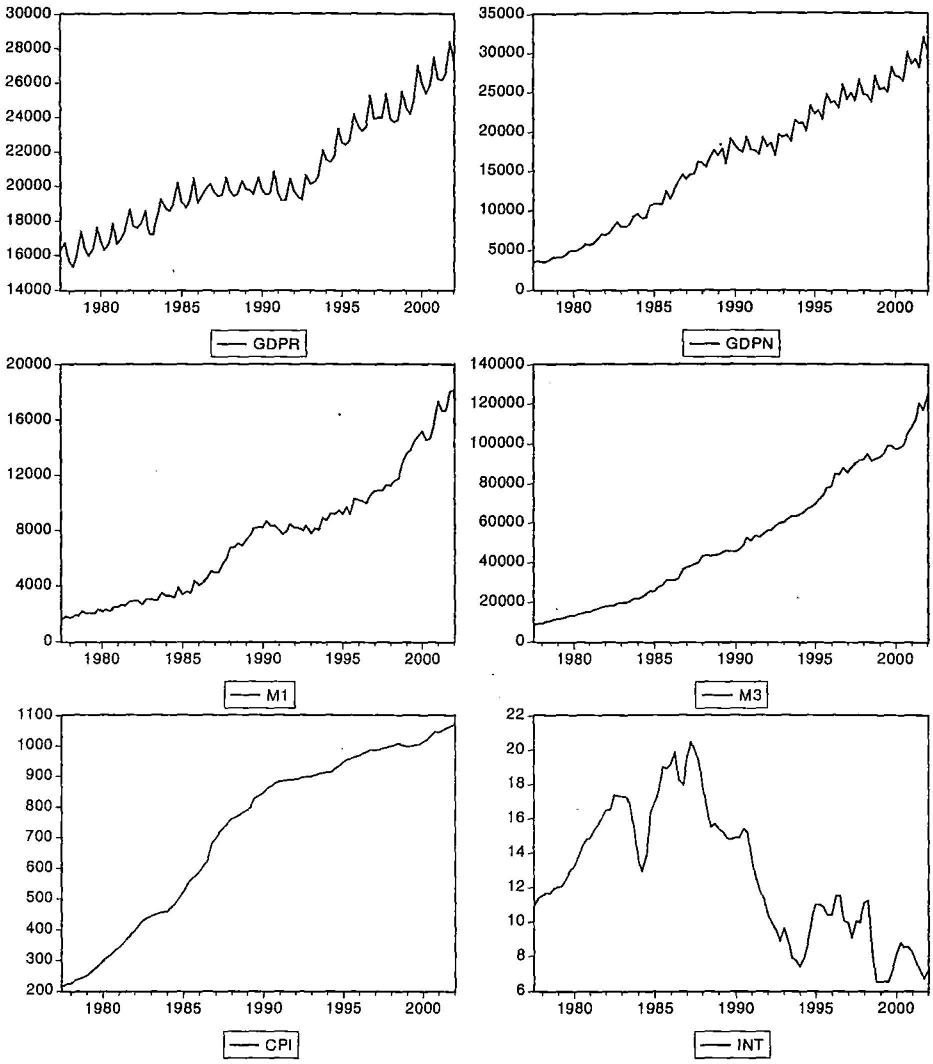
[2] See, for example, Boivin and Giannoni (2002); Kahn et al. (2002); Kuttner and Mosser (2002).

[3] Written reply from one the Reserve Bank's officials when asked about the differences in the series.

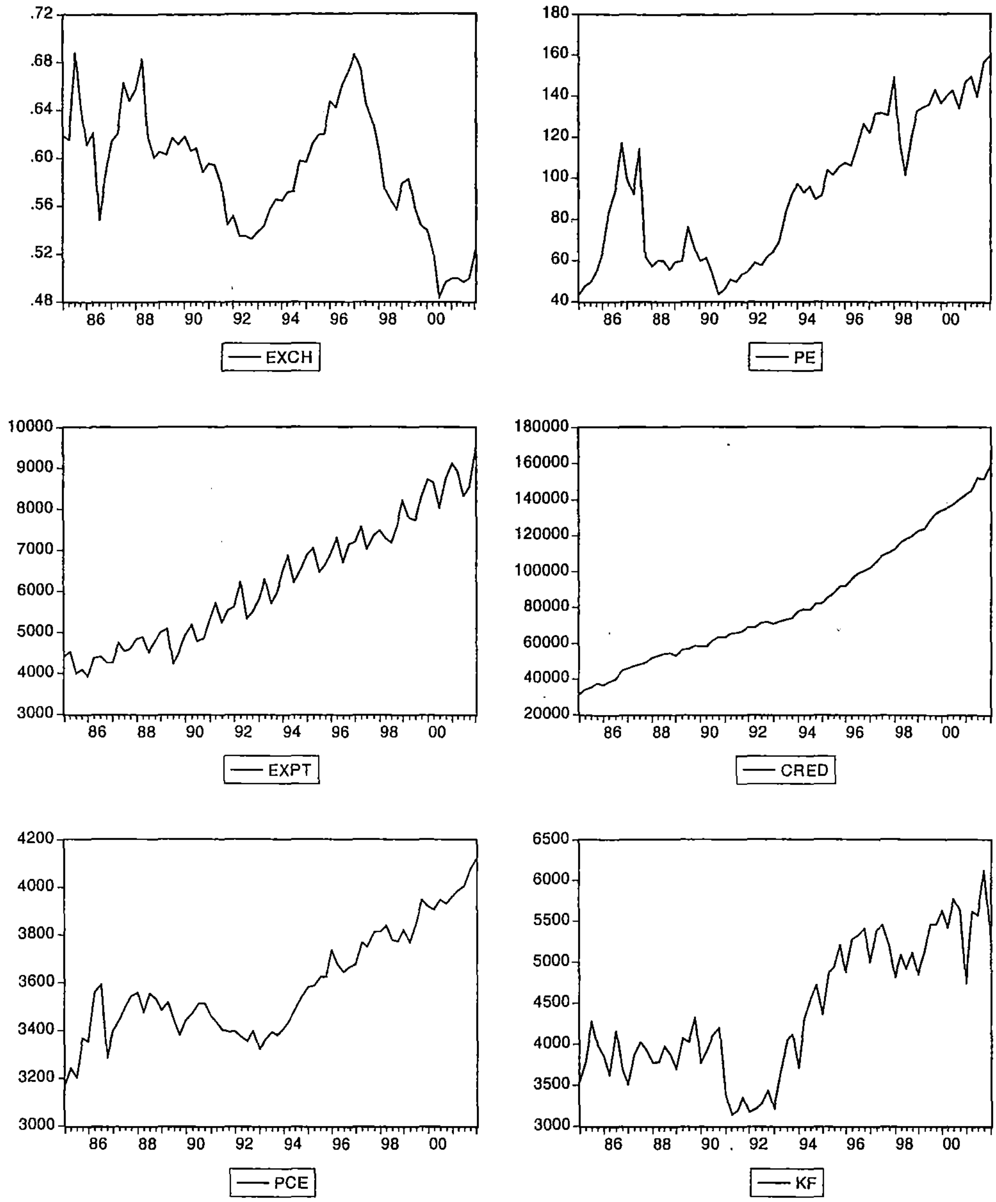
Fig 6.2.1 Data :1977-2002 sample



GDPR = Real GDP; GDPN = Nominal GDP;
M1 = currency + cheque account deposit; M3 = M1 + all financial institution deposits;
CPI = consumer price index; INT= mortgage housing interest rate

in the analysis of the monetary transmission mechanisms. The first set of data has a longer time span than the second set because compilation of some data in the second set is more recent, e.g. exchange rates and share price indices, and so it is necessary to shorten the other series as to be consistent with these shorter series. Actually the annual data on these are available and they go back further in time but the quarterly data is considered more appropriate for the analysis because the impacts of some government polices could be felt

Fig 6.2.2 Data : 1985-2002 sample



Note: EXCH = trade-weighted exchange rate index (TWI); EQUITY = share price index;
EXPT = exports of goods and services; CREDIT = domestic credit
PCE = private consumption expenditure; KF = gross fixed capital formation.

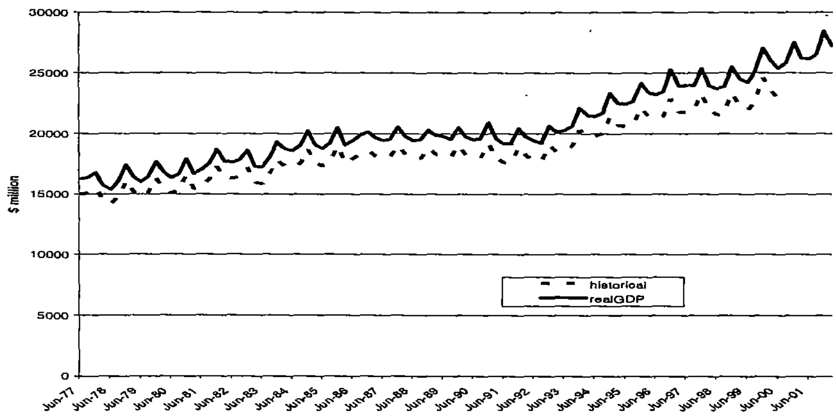
in less than a year, i.e. have shorter time-lag[4] than a year. Another advantage of quarterly data is of course the increase in the number of observations. The first data set has about 100 observations while the second sample has just over 60 observations. This second sample is

[4] This term will be used to denote the period in which a variable shows a significant response to an exogenous shock. For example, when we say output has a time-lag of three quarters, we mean that output shows a significant response in the 3rd quarter following an exogenous shock. Another equivalent term is the lag-period.

not so large therefore this may give inflated variance (standard error) or imprecise estimates but the point estimates are still unbiased. In the subsequent analysis variable names that start with a 'D', e.g. DM1 or DGDPR, etc., means the variables are in first-difference. If the variable has a prefix 'DD', this means the variable is in second-difference.

Data for real output uses the more recent GDP chain-volume series[5] that started in June 1987 so in order to extend this series back to 1977, the starting point of the analysis, the 'historical' GDP data[6] movement is used to estimate the corresponding chain volume data. Quarterly data for nominal GDP started in June 1982 and so estimates have to be made for the earlier period as well. This is done using movements in real GDP and the CPI as the deflator. Both GDP series are actual (unadjusted) data and obtained from Statistics New Zealand.

Fig 6.2.3 Real GDP



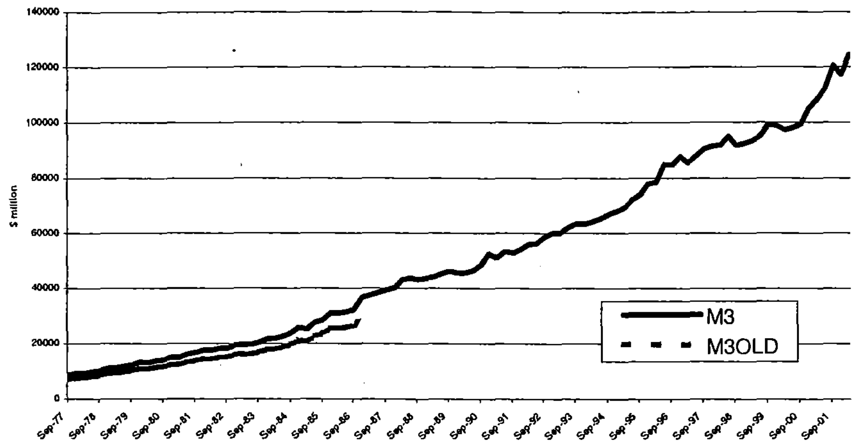
historical = real GDP series that stops in June 2000
real GDP = ongoing chain-volume series that starts in June 1987

Money aggregate M3 (see Fig 6.2.4) has its definition changed in 1988 and so there is some discontinuity in the series. To join the two portions of the series, i.e. the ongoing series that started in 1988 with the historical portion, the ongoing data series is regressed backward for five quarters using simple linear regression[7] and then movements from the historical series is applied on the last quarter's estimated data and the process repeated on each subsequent estimated data until 1977. The resulting series seems reasonable with no distinct breaks or abnormal trends. No adjustment is made to money aggregate M1. Both monetary

[5] Production –based and uses the 1995/96 prices—and note that the term 'chain-volume' is the modern term for real GDP.
[6] This series ends in June 2000.
[7] This is because there is no data for the whole of 1987.

aggregates have been downloaded from the Reserve Bank of New Zealand internet webpage.

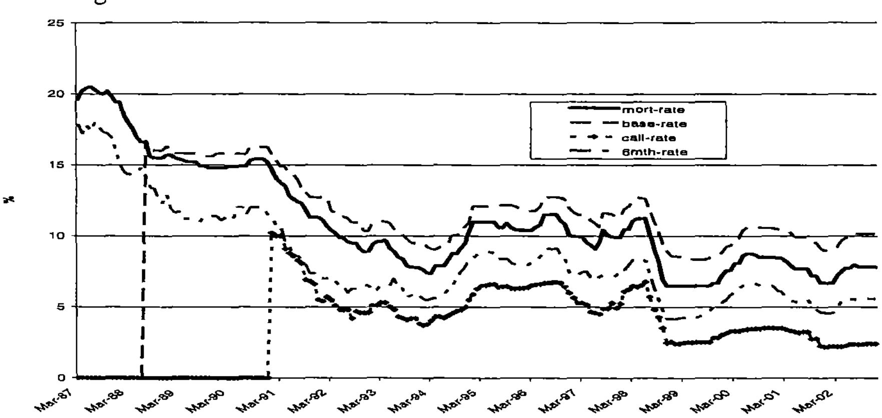
Fig 6.2.4. Money M3



M3 = ongoing M3 series that starts in 1988
M3OLD = historical M3 series that is used to estimate portion of the ongoing series

Mortgage rate is used as a proxy for interest rate. Short-term interest rates would have been used[8] but the series do not go far back enough—besides, all the interest rates movements are basically similar (see Fig 6.2.5). This similarity in interest rates is noted also by

Fig 6.2.5 Interest rates



mort-rate = first mortgage housing rate; base-rate = base lending rate
call-rate = call deposit rate; 6mth-rate = six month deposit rate

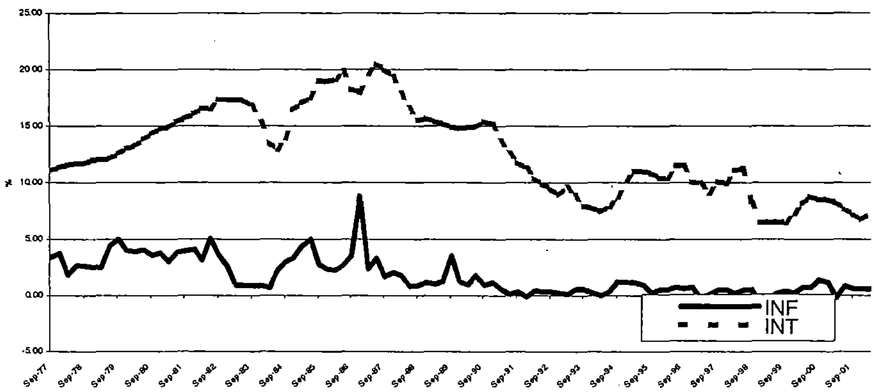
Friedman (2000) who says, *"Although the central bank directly controls only the interest rates on short-term instruments, like Treasury bills, the longer-term interest rates applicable to borrowing for these purposes mostly move in the same direction as short-term*

[8] Most central banks use the short term interest rate in conducting their monetary policies.

rates because banks and other investors are able to substitute among different debt instruments in their asset portfolios". Moreover, several studies have also found that long run relationships between long-term and short-term interest rates are stationary[9].

Price index is the Consumer Price Index (CPI) and the inflation rate shown below in Fig 6.2.6 is simply calculated from the percentage change in the quarterly indices, i.e. the quarterly inflation rate is used rather the usual annual rate of inflation as to be consistent with the other first-differenced data.

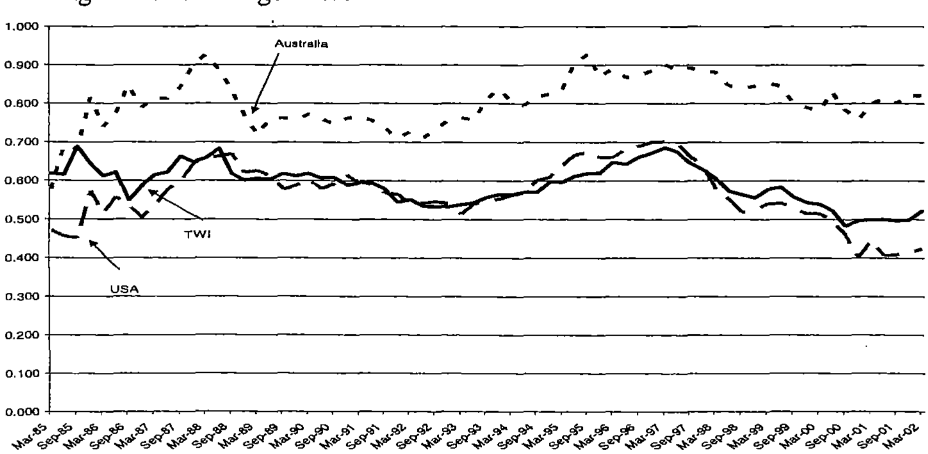
Fig 6.2.6 Inflation and interest rates



INF = quarterly inflation rate; INT = mortgage interest rate

For the exchange rate we use the trade-weighted index (TWI). This has very similar movements with the New Zealand—US exchange rate (Fig 6.2.7).

Fig 6.2.7 Exchange rates



Note: TWI is divided by 10 in order to have comparable magnitude with the other rates.

[9] As cited in Hubrich and Vlaar (2000).

For the equity price data we use the New Zealand share price unadjusted index. This share price index movement is very similar to the movement of the industrial share price index so using either one should not make much difference in the analysis. The domestic credit data series is used in the credit channel analysis, and for real investment data, the gross fixed capital formation[10] provided by Statistics New Zealand Statistics is used. For exports data, the chain volume series expressed in 1995/96 prices is used—also provided by Statistics New Zealand.

Looking at the time plots of the series, some series, like GDP, exports, money aggregates, etc. show distinct upward trending patterns suggesting they have either a stochastic or a deterministic trend. The others are more erratic and possibly have stochastic trends. The only series that seem to display some form of mean-reversion are the inflation rate, interest rate and the exchange rate, however 'formal' unit root tests, such as the ADF, PP and the KPPS tests, will determine the stationarity status of these series.

Before going to the formal unit root tests, it is useful to remark further on the features of the major economic variables like GDP and inflation. As can be seen from Fig 6.2.1, both real and nominal GDP series show pronounced seasonality pattern in addition to the upward trending pattern. Seasonality pattern reflects a stylised fact of the economy, i.e. it shows how the economy tends to move in a regular pattern that could be due to weather conditions or due to the country's unique spending/production pattern. This poses the question of whether the series needs to be deseasonalised or not in the analysis. In general, for long run analysis the deseasonalised series are more convenient to work with, but in short run analysis, the seasonal pattern is better left as it is because it reflects what actually took place and should make the analysis and interpretations more realistic. Enders (1995) discusses two other problems related to deseasonalised data; the first is that the seasonal pattern might remain even if the data has been seasonally adjusted, and the second is that any seasonal adjustment process involves two steps which could give inaccurate coefficients if estimation is made separately in each step—and as he puts it, "*In such circumstances, it is wise to avoid using seasonally adjusted data*".

[10] In constant prices.

Of the two output series, nominal GDP displays a steeper trend[11]—in fact, real GDP shows some levelling off in the 1984-92 period, followed by a distinct rise that continues until the end of the study period. This 'levelling off' period coincides with the period when New Zealand government undertook major economic reforms (see Dalziel & Lattimore, 2001; Scolly & St John, 2000) and has been the cause and focus of heated debate between those who claim the reforms have been too drastic and too rapid resulting in substantial output loss, and those who generally supported the changes[12].

Though trending upwards like other series, price index series (CPI) tends to be more concave in shape. This implies that the rate of change (equivalent to inflation rate) is getting more subdued towards the end of the study period. This diminishing rate is quite obvious when we look at the inflation rate graph in Fig 6.2.6—as of the early 1990s the rate has indeed come down to less than 2 per cent. In fact, in some periods the rate is either zero or negative. This coincides with the adoption of the Reserve Bank Act 1989 that explicitly states 'low inflation' as the sole objective of monetary policy[13]. Looking at the same graph (i.e. Fig 6.2.6) we see a distinct spike in the inflation rate around 1987—again this coincides with the time the GST was introduced—this, and other characteristics noted above, will be taken into account when carrying out more formal tests on the data or when running regressions and making interpretations.

6.2.2 Unit-root test results

The upward trending and erratic pattern of some of the time series plots in the figures above suggest nonstationarity of the data; however to confirm this visual assessment, the unit root tests are performed[14] and the results are summarised in Table A6.2.1 (for New Zealand variables) and Table A6.2.2 (for Australian variables) in the appendix. Looking at Table A6.2.1, we see that indeed, apart from the inflation rate and nominal GDP, the ADF and the PP test results do not reject the null of nonstationary for all variables in level. This is confirmed by the KPPS test results that reject the null of stationarity for all series—apart

[11] This is expected given nominal GDP reflects movement in price as well.
[12] Some interesting papers include that of Evans et al. (1996) which summarises key aspects of the reforms and lessons to be learnt; Dalziel (1999) who estimates NZ$210 billion in loss output between 1985 and 1998 because of the reforms, and Podder and Chatterjee (1998) paper that focuses on income inequality resulting from the reform.
[13] See Dalziel & Lattimore (2001).
[14] Using Eviews 4.0.

from the two variables indicated. In first-difference all the results indicate stationary however for real GDP the results are mixed: The PP and KPSS tests suggest stationary but the ADF test indicates nonstationary.

Inflation rate is stationary according to all the three unit-root tests, but tests on nominal GDP have some mixed results. The ADF, PP and KPSS test results using the 'constant and trend' formulation, suggest stationarity, however with only the 'constant' included, the results imply nonstationary. Now looking more carefully at the regression results of both tests, the time trend is significant implying the presence of a deterministic trend. When nominal GDP is in first difference, nonstationarity is still evident thus confirming the presence of a deterministic trend so the series is consequently detrended by regressing it on a constant and linear time trend variable. The residuals is saved and used as the detrended nominal GDP[15]. Unit root tests are applied again on this detrended series and this time the results show that this series is stationary—as expected, i.e. the series is a trend-stationary series and not a difference-stationary series. This could have serious implications for the neutrality test methodology proposed by Fish and Seater (1993) that requires difference-stationary series.

Checking the ADF and PP test results of the second sample, we see from Table A6.2.1 (b) that all variables in level do not reject the null of nonstationary. In the case of the KPPS test results, similar conclusion is obtained except for the exchange rate series that does not reject the stationary null. This mixed test results often happened in empirical works and this is why it is useful to have three (or more) different tests so that one have more evidences to consult before deciding whether the variable in question is stationary or nonstationary. Looking at the test results in Table A6.2.1 (b), all the first-differenced variables are stationary except the credit variable that seems to show some mixed results. According to the ADF and PP tests, the credit variable in first-difference is stationary but according to the KPPS test, it is nonstationary[16], however in second-difference, all the tests indicate stationary.

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[15] Discussed in Enders (1995, p. 179).

[16] This contradictory result is consistent with what Maddala (2001, p. 552) said, *"Tests for unit roots with the null hypothesis being stationary (no unit root) have also been developed and they often give results contrary to those of the unit root tests with the unit root as null"*.

6.2.3 Seasonal unit roots

A6.2.3 in the appendix reports the results of the seasonal unit root tests[17] performed on real GDP and nominal GDP. For real GDP, the first hypothesis $\pi_1 = 0$ is not rejected at both the 5 per cent and 1 per cent significance level suggesting the presence of nonseasonal unit root[18]. The other hypotheses, $\pi_2 = 0$ *and* $\pi_3 = \pi_4 = 0$, are both rejected implying that there is no seasonal unit root either at the semiannual frequency nor at the annual frequency. With nominal GDP, the hypotheses are all rejected implying the presence of both nonseasonal and seasonal unit roots, however we know from the previous unit-root tests that this series has a deterministic trend.

Seasonal unit root test is carried out only on GDP series because the other series do not show distinct seasonal pattern (see Fig 6.2.1). Furthermore, all the series become stationary upon first-differencing hence there is no need to seek other detrending methods.

6.2.4 Structural break test on output

Perron's test, as explained in the Methodology Chapter, will be used here. For ease of reference the alternative equation that will be estimated is reproduced below.

$$Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \beta t + \gamma_1 DUP + \gamma_2 DUL + \gamma_3 DUS + \sum_{i=1}^{k} \eta_t \Delta(Y_{t-i}) + \varepsilon_t \tag{6.1}$$

The estimated results are shown in Table 6.2.1. Note Y_t is replaced by GDPR in the table below and *DUP, DUL* and *DUS* are all dummy variables.

The diagnostic test results suggest the residuals of Equation (6.1), with k = 4, are independent, serially uncorrelated and homoscedastic so we can now proceed to test the null hypothesis of a unit root in real GDP. The test statistic is (0.4827-1)/0.1325 = -3.9. Compared to the 5 per cent critical 't' value of -4.24[19], we do not reject the null hypothesis of a unit root process[20], i.e. real GDP series has a unit root. The insignificance of the trend function also confirms the presence of a stochastic trend rather than a deterministic trend.

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[17] Follows the method of Hylleberg et al. (1990) described in the Methodology Chapter.

[18] This is consistent with the ADF, PP and the KPPS unit root test results.

[19] Extracted from Table VI.B in Perron (1989).

[20] This is different to Sanyal and Ward (1995) result of -6.5686 which rejects the null hypothesis of unit root. It is important to note however that Sanyal and Ward study covers 1967 to 1991, and the break point, which is endogenously determined, is between 1975 and 1977.

Table 6.2.1 Empirical results of Perron test for real GDP series
(1985:1 to 2001:1)

Variable	Coefficient	Std. Error	*t*-value	*p*-value
Constant	10305.8100	2610.1630	3.95	0.0002
GDPR(-1)	0.4827	0.1325	3.64	0.0006
Trend (t)	-2.9277	7.6522	-0.38	0.7035
Pulse dummy (DUP)	-527.6092	348.7773	-1.51	0.1362
Level dummy (DUL)	725.0779	201.4192	3.60	0.0007
Slope dummy (DUS)	89.8462	24.8401	3.62	0.0007
DGDPR(-1)	-0.0455	0.1451	-0.31	0.7552
DGDPR(-2)	-0.1729	0.1277	-1.35	0.1814
DGDPR(-3)	-0.2824	0.1128	-2.50	0.0153
DGDPR(-4)	0.5338	0.1044	5.11	0.0000

Residual Diagnostic Tests:
Breusch-Godfrey LM serial correlation test: $F(5, 62) = 1.82$ (0.126)
ARCH test: $F(4, 60) = 1.72$ (0.158)
Jarque-Bera LM normality test = 0.169 (0.919)

Because of the presence of the unit root, the standard t and F–ratio tests cannot be applied to the coefficients of the dummy variables. Notwithstanding this, it is interesting to note the significance of both the level and slope dummies at the 5 per cent level which implies there is significant change in the level and slope of real output around the 1991/1992 period.

Because Australian output does not display any obvious break in its graph, the structural break test will not be applied to it.

6.3 Neutrality and superneutrality tests

6.3.1 Overview of the tests

Because most of the series are nonstationary (or have a stochastic trend), their first difference will be used[21] in the following neutrality tests, but unlike most studies that use logarithmic and deseasonalised figures, the data here are generally not adjusted. The intention is to be able to read off the coefficients and the responses using the same units as the 'raw' data—and which presumably policy makers and laymen alike could easily relate to. And with regard to seasonal feature, this is the actual characteristic of the data and reflects what actually happened so rather than using a 'smoothed out' version of the data, unadjusted data is used here—besides, unit root tests will have more power in this case[22]. However, in the case where the responses show very pronounced seasonal pattern, thus making it difficult to read off the numerical values, then seasonal dummies will be added to the model to 'smooth' out the fluctuations. But the application of the dummy variables at this stage is considered preferable because it effectively means that all the variables in the model are subjected to a uniform deseasonal adjustment process.

Although the focus in this first part of the analysis is on the long run neutrality tests, analysis of the impulse (or short run) responses will also be made because of the general and ongoing interest on the short run theories which include the IS-LM curves, Phillips curve, the Taylor rule, and so forth. In fact, a lot of assumptions have been made regarding short run behaviour of variables in theoretical models leading up to different conclusions, which in some cases became the dividing line between the different macroeconomic schools. For example, the New Keynesians believe that prices are 'sticky', i.e. slow to adjust, whereas the Classicals always believe in a 'continuous market clearing' situation. Then there are those of the 'rational expectation' school who insist that only 'unexpected' policy that has real effect, i.e. systematic policy has no impact because people are rational therefore they will change their operations as to counter any adverse impact of the new policy announced by government. Therefore the analysis of the impulse (or short run)

[21] As pointed out by Manchester (1989), *"First-differencing ....yields more nearly stationary series, enhancing the reliability of the results".*

[22] Discussed in Maddala and Kim (1998, p. 365).

responses is considered useful in this respect. As Bullard (1999) observed, *"How long such a process takes, and what might happen in the meantime, are hotly debated issues".*

The first bivariate combination is between money aggregate M1 and real GDP. This will be followed by other combinations, such as M1 and nominal GDP, real GDP and M3, M1 and price, etc. These combinations are not arbitrarily selected—rather they have important theoretical basis as well as important implications for policy formulation. This should become apparent when the individual models are estimated and analysed in the subsequent sections.

6.3.2 Money M1 vs Real GDP

The relationship between money supply and real output is one of the more common bivariate combinations that has been investigated by many researchers in the past including Fish and Seater (1993) who first developed the framework for testing the long run neutrality of money.

Testing the lag length

The unrestricted bivariate VAR incorporating money aggregate M1 and real GDP in first-difference is initially estimated with 12 lags. In addition to the constant, the seasonal dummies, S1, S2 and S3 are included in the model in order to smooth out the pronounced seasonal fluctuations. The time trend is not included because neither differenced series shows any significant trending pattern. The AIC and SBC tests[23], as well as the adjusted likelihood ratio (LR) test, select the VAR of order 4. Consequently the model is reestimated with 4 lags and looking at the diagnostic test results in Table A6.3.4 and Table A6.3.6 in the appendix there is no evidence of serial correlation and heteroscedasticity in the individual equations, i.e., the model specification seems adequate and so we choose lag length of four quarters.

[23] Results reported in A6.3.1.

Cointegration test result

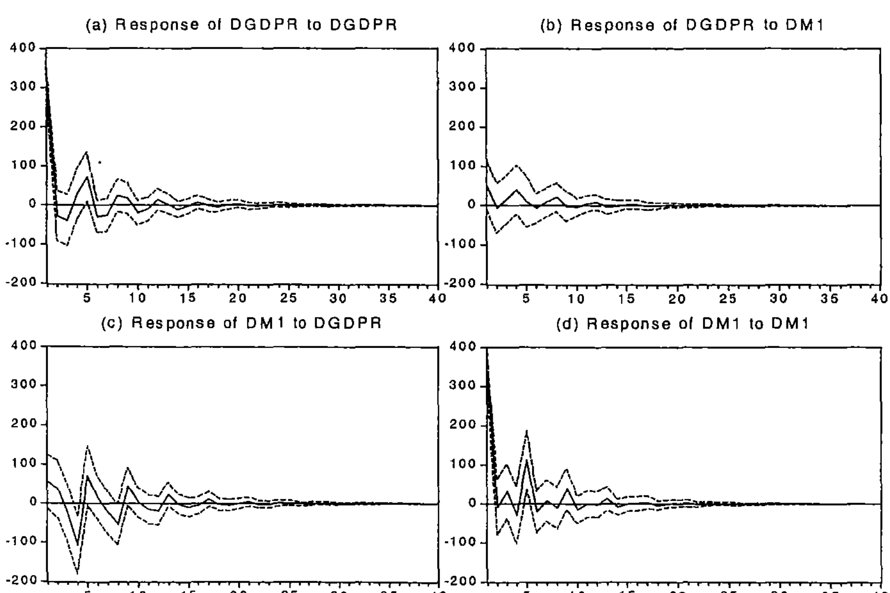
The next test is for cointegration relationship between real GDP and money M1 in levels. The lag length selected by the AIC and SBC tests[24] is 5 and the cointegration test results, using Johansen ML approach, are presented in Table A6.3.2 in the appendix. Both the maximum eigenvalue test and the trace statistic test do not reject the null of no cointegration (i.e. $r = 0$) at the 95 per cent confidence level. As to the model selection tests, the three tests, i.e. SBC, HQC and AIC select $r = 1$. The decision is to assume no cointegration because Johansen test is more specific to the cointegration issue whereas the model selection criteria are more general—besides, most computer packages, like Eviews, use only the eigenvalue (Johansen) cointegration tests.

With no cointegration relationship found, the model will be a straightforward VAR in first-difference with 4 lags, a constant, and seasonal dummies. The estimated unrestricted VAR equations are shown in Table A6.3.3 and Table A6.3.5 in the appendix. Note that the real GDP equation shows significant seasonal effects but not the money supply equation.

Short run analysis

From Fig 6.3.1 below we see that the responses all dampen out to zero after the 10th quarter

Fig 6.3.1 Impulse responses



[24] Follows testing procedure in Microfit 4.0 manual, p. 291.

or so implying the stationarity of the differenced data, whereas the long run responses in Fig 6.3.4 remain at some constant value after some initial fluctuations suggesting a 'permanent' change has occurred. It is this 'permanent' change that Fish and Seater (1993) long run neutrality test statistic relies on.

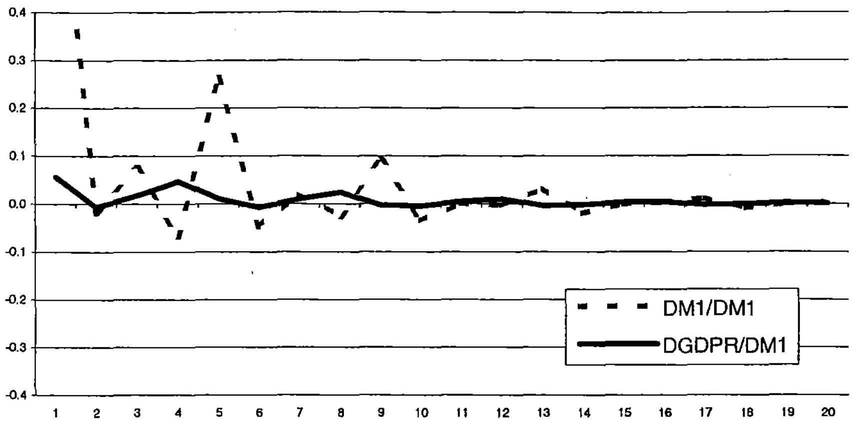
One problem with Fig 6.3.1 is that it is difficult to compare and comment on the contemporaneous responses of real output and money supply to the same shock because the responses are not in the same scale and not on the same graph. To overcome this, Fig 6.3.2 and Fig 6.3.3 are constructed using standardized units[25] and they show output and money supply responses due to the same exogenous shock, i.e. Fig 6.3.2 shows the responses due to monetary shock and Fig 6.3.3 shows the responses due to real output shock. In order to be consistent, the percentage unit will be used throughout the analysis but the tables and the figures will still show 'standardized unit'. A unit of 0.2 therefore means 20 per cent of one standard deviation—likewise a unit of 0.05 is 5 per cent of one standard deviation. Note also that DM1/DM1 is the response of money M1 to its own shock and likewise, DGDPR/DM1 stands for real GDP response to money M1 shock. This applies to all subsequent response analysis. Furthermore, for brevity purposes the first-difference term or the 'D' prefix may be omitted in the following table headings as well as in the discussion.

We see from Fig 6.3.2 that in the first quarter after the monetary shock[26] output response is positive however as the response of money aggregate declined dramatically reaching zero level in the 2nd quarter, it seems to drag down with it output, i.e. real output is zero at this time also. Output response then gradually rises reaching its peak of 5 per cent (or $41million) in the 4th quarter —the same time when monetary aggregate reaches its minimum. Then as output starts to decline, monetary aggregate starts to rise again, i.e. demonstrating clear evidence of countercyclical behaviour. This is consistent with Buckle et al. (2003) statement that *"Monetary policy has been generally countercyclical, thereby reducing business cycles and inflation variability"*.

[25] Each response is divided by its own standard deviation and because it is in proportions, it can be represented as percentages as well. This transformation is known as the 'normalization' process and allows the responses to be plotted on a single scale. Note we do not show the confidence band because it might obscure the responses—besides, confidence band around the responses of stationary variables are not that useful because they generally encompass the horizontal axis.

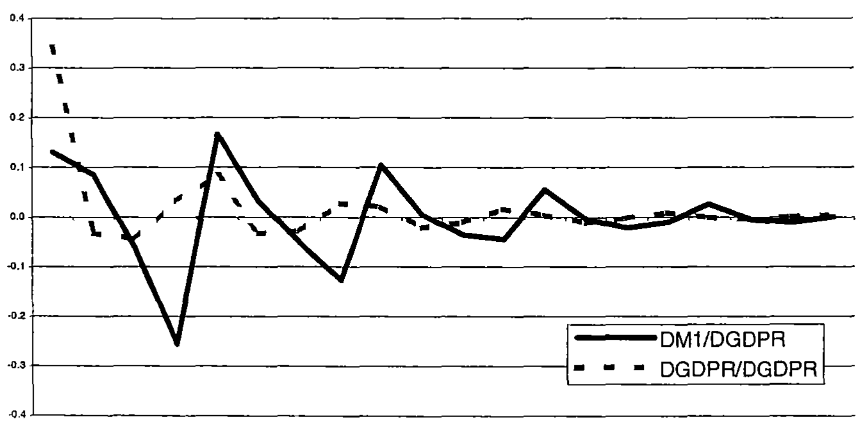
[26] Of one standard deviation and which is equivalent to $421 million.

Fig 6.3.2 Impulse responses of real GDP and money M1
to money M1 shock



Now we will examine how output and money respond to a real shock (see Fig 6.3.3). This is important because it will show whether or not money is endogenous to output movements.

Fig 6.3.3 Impulse responses of real GDP and Money M1
to real GDP shock



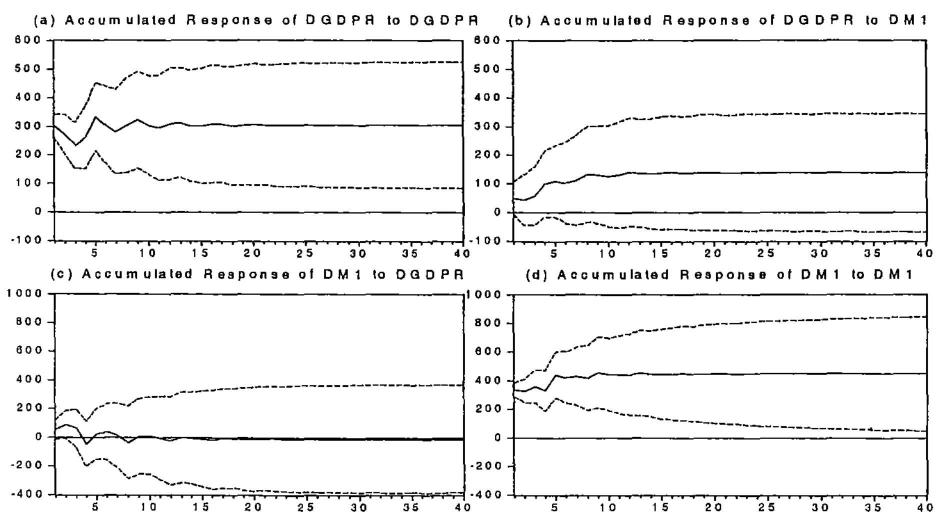
As can be seen from Fig 6.3.3 above, the responses of output and money supply variables are quite different to the responses observed in Fig 6.3.2, i.e. the responses due to monetary shock are different to the responses due to real shock. Although not very obvious, the responses here seem more procyclical than countercyclical in the sense that as output increases so does the money supply. In the 5th quarter, for instance, both reached their peak; output response is 8 per cent (or \$72 million)[27] and money supply response is 17 per cent (or \$70 million). In other words, when there is a real shock, the money supply seems to be accommodative (or endogenous) in the sense it increases to cater for the extra output produced in the economy[28]. However the pronounced negative response of monetary aggregate to a real shock is suggestive of the central bank's concern and effort to stoke off any inflationary pressure arising from output increase.

In terms of the relative impact of shocks on output, the real shock invokes a maximum response of 8 per cent from output while the monetary shock produces a 5 per cent response. Thus we see that a real shock impact on output is about twice that of the impact of a monetary shock. But in terms of the lag-period, output response to the monetary shock has a shorter lag-period (four quarters) compared to output response to real shock that requires five quarters.

Long run analysis

Turning our analysis to the long run responses in Fig 6.3.4, we see that the point estimate of the long run response of output to a permanent monetary shock is \$139 million (16 per cent). So while in the short run the peak response of output to monetary shock is just \$41

Fig 6.3.4 Long run responses



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[27] See Table A6.3.7.

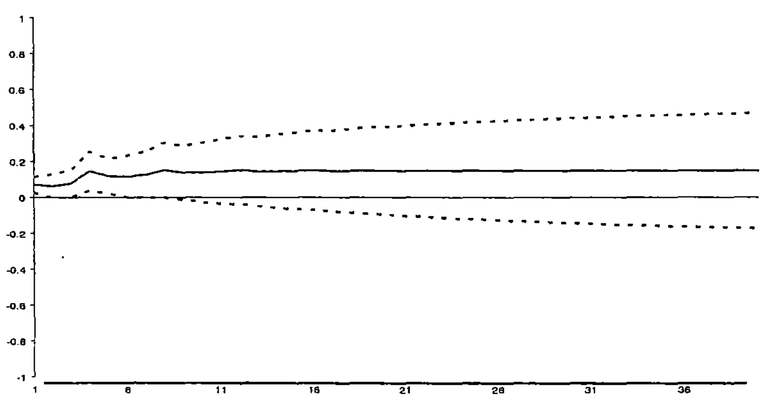
[28] This endogeneity of money supply is consistent with the Bernanke et al. (1997) observation that most of the observed movement in the instruments of monetary policy is endogenous.

million (or 5 per cent), the long run response is actually $139 million. Although this magnitude seems relatively high, the 95 per cent confidence band still encompasses the zero axis, i.e. the response is not statistically different from zero at the 5 per cent significance level.

Another interesting observation is that of the money supply response to output shock (see part (c)). Initially after output shock money supply response is positive but after five to six quarters, it returns to equilibrium. This would seem to confirm the notion that money is endogenous, at least in the short run.

To apply the Fish and Seater LRD formula, we need to divide the long run response of output due to a monetary shock by the long run response of money supply due to the same shock—these are commonly known as the long run multipliers. The result is shown in Fig 6.3.5 and obviously the LRD statistic[29], after some small fluctuations in the first 10 or so quarters, stabilises around 0.15. This is not statistically different from zero taking into account the 68 per cent confidence interval[30].

Fig 6.3.5 Computed LRD test statistic



It is interesting however to note how the long run responses do not actually die out to zero as classical theory predicts. This is a stubborn or persistence feature that has been noted by several researchers and which prompted Giodarni (2001) to say, *"the output response to*

[29] How this is calculated is explained in Chapter 5.

[30] The confidence interval for the LRD is calculated from the confidence intervals of the two long run multipliers provided by the Eviews computer program. The Monte-Carlo simulation option is the one used in this analysis.

monetary shocks remains stubbornly persistent". He argues that the model should incorporate output gap as one of the regressors, so in a way we can say that this persistence profile is a symptom of variable omission or misspecification. However no attempt is made here to correct for this phenomenon because the output gap is a difficult construct to measure[31]—besides, the objective of this study, at least in this first part of the analysis, is simply to investigate monetary neutrality and other relevant classical hypotheses.

By way of summary we conclude that long run monetary neutrality is not rejected when we use real GDP and money aggregate M1 but the persistence of output response is still very much evident. Also the counter-cyclical impulse responses are consistent with the notion that in the short run monetary policy is used to stoke off inflationary pressure. In order to see whether there is in fact inflationary pressure when output increased, a trivariate (or higher order) VAR model incorporating price or inflation would be appropriate but this will be left to the later part of the analysis. There is also evidence that money supply increases after real output shock in line with the endogenous theory of money, at least in the short run. This endogeneity behaviour of money would lend empirical support to the Post-Keynesian claim that money supply is seen to accommodate itself to the needs of trade (Snowdon et al., 1994, p. 373). So what we are seeing here is that there is empirical evidence that money is exogeneous and endogenous as well, a finding that would be consistent with Cagan (1993) results.

6.3.3. Money M1 vs nominal GDP

According to Fisher and Seater (1993), *"if nominal GDP is not integrated, then 'permanent'*[32] *changes in money cannot be associated with permanent changes in that variable because the latter do not exist"*. And from the unit root test results[33] we see that the nominal GDP variable has no unit root. This would have prompted us to skip the test however for the sake of completeness, in terms of getting results from the interactions of both the integrated and nonintegrated variables, this model will still be estimated and the responses examined as done in the previous analysis. Even if we get no response or very

[31] This problem is also raised by Mahadeva and Sinclair (2001, p. 9) in their summary when they say, *"The authors* (referring to Boyd and Smith*) suggest that the errors in measuring unobservable variables, such as potential output, largely explain why our estimates of the transmission mechanism are so unreliable"*.

[32] This is a hypothetical concept needed for the LRD test statistic.

[33] See Table A6.2.1.

little response from nominal GDP, this information is still useful in offering direct empirical evidence to the theory of 'stationarity' widely discussed in many standard econometric texts[34]—namely that stationary or nonintegrated variables cannot sustain or propagate shock effects. As pointed out by Kuttner and Mosser (2002), *"negative findings are often as informative as positive ones"*.

The general approach used in testing neutrality in the previous analysis (i.e. between real GDP and money M1) will be followed here, except now real GDP is replaced by nominal GDP. However, there will be no cointegration test because of the nonintegrated property of nominal GDP as well as the different orders of integration of the two variables.

Testing the lag length

From Table A6.3.8, AIC selects VAR of order 7 while SBC chooses order of 1. The adjusted LR test on the other hand suggests VAR of order of 4. Given the mixed results, different orders are tried and the selection is based on the model that gives the optimal outcome in terms of no serial correlation and no heteroscedasticity. After running several regressions, the model with 6 lags seems to give the best diagnostic test results. The estimated regression results, with the time trend[35] and seasonal dummies included, are presented in Table A6.3.9 and Table A6.3.11 in the appendix.

Short run analysis

The impulse responses in Fig 6.3.6a apparently do not die out quickly implying nonstationarity of the data. In order to avoid any problem this may have on the analysis the series is shortened as to exclude the portion of nominal GDP that has been estimated i.e. the model is reestimated with the series starting in 1985. The impulse responses of the modified model are shown in Fig 6.3.6b—and as can be seen, the responses die out quite quickly suggesting the variables are stationary this time—at least the responses are more consistent with the responses in the previous analysis. Consequently the following analysis will use a shorter time period, i.e. the series will start in 1985.

[34] See for example, Enders (1995) and Maddala and Kim (1998).

[35] This time trend is added in order to remove the deterministic trend component of the series.

Fig 6.3.6a Impulse responses (1977-2001)

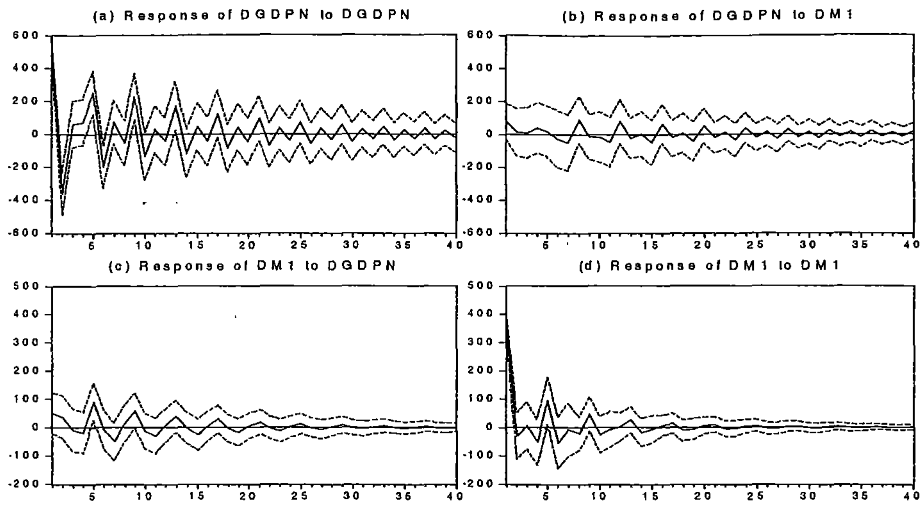
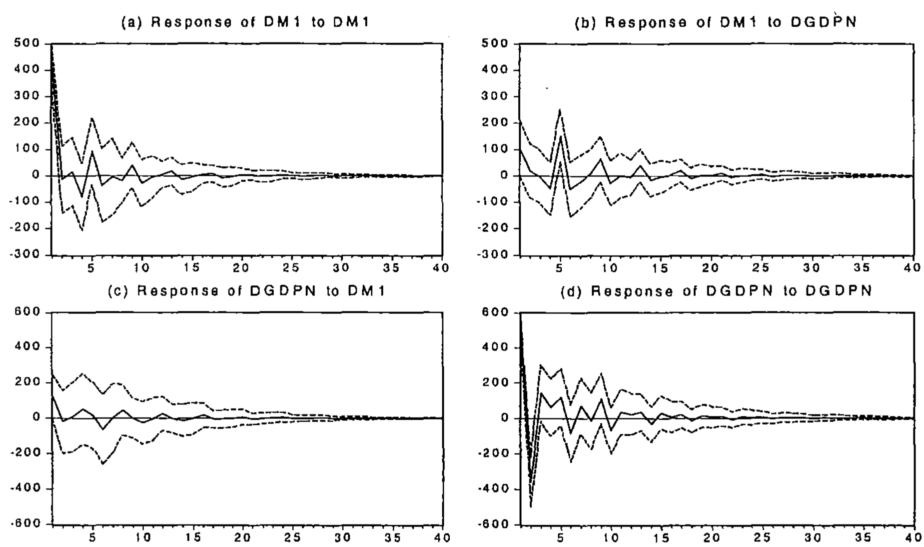
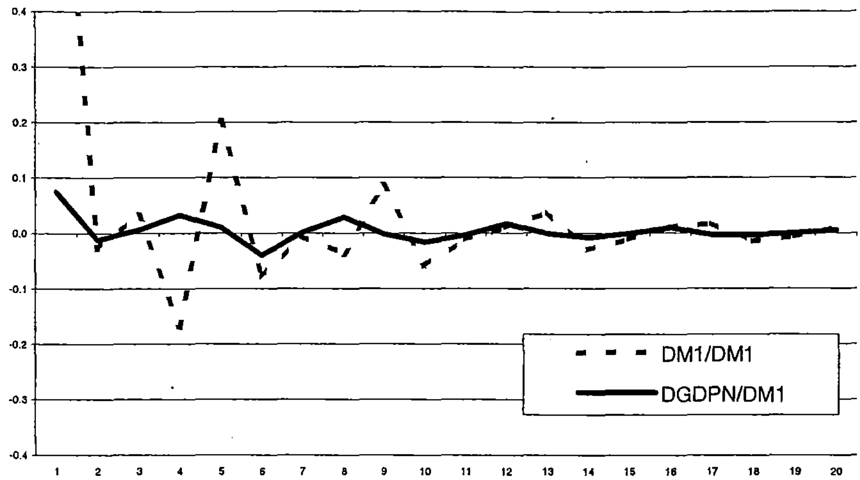


Fig 6.3.6b Impulse responses (1985-2001)



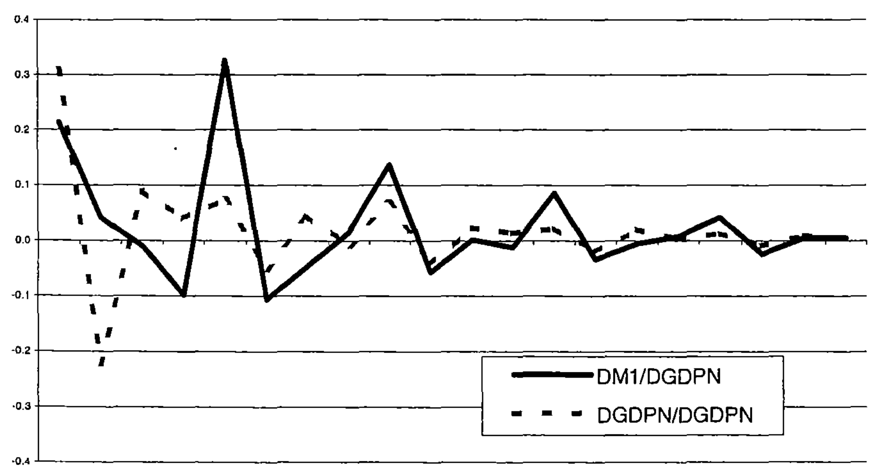
The contemporaneous responses following a money shock are shown in Fig 6.3.7 and the pattern and the magnitudes are roughly the same as those in Fig 6.3.2. For instance, there is evidence of countercyclical movements with nominal output peaking in the 4th quarter, 8th quarter, etc., while money supply peaks in the 5th quarter, 9th quarter, and so forth. That is, when one peaks, the other reaches its trough, and vice versa. The peak response of nominal output is 4 per cent which is very close to the real output peak response of 5 per cent noted in the previous analysis.

Fig 6.3.7 Impulse responses of nominal GDP and money M1 to money M1 shock



As to the responses following an output shock these are shown in Fig 6.3.8. There is some evidence of procyclical movements here—again the same as in the previous analysis (see Fig 6.3.3). For example, in both figures, both nominal output and money supply peak in the 5th and 9th quarters. The response of money aggregate this time however is much higher

Fig 6.3.8 Impulse responses of nominal GDP and money M1 to nominal output shock



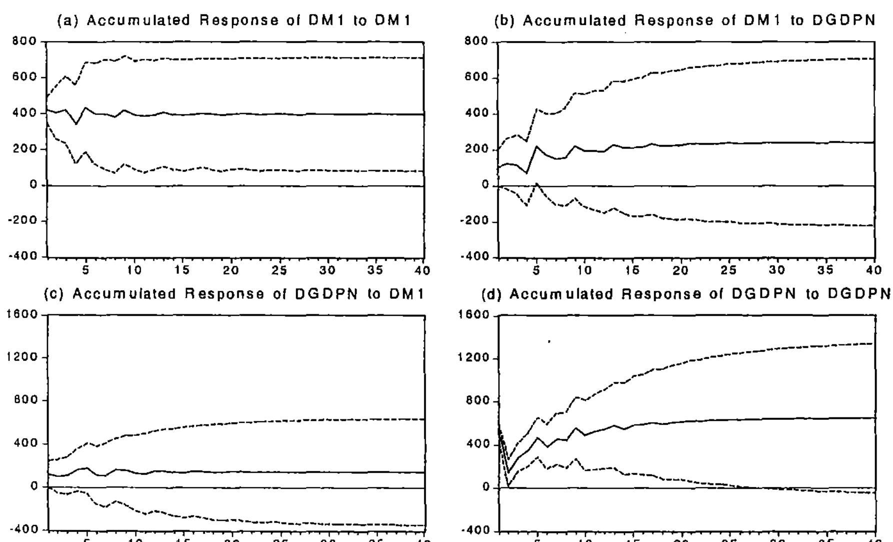
than when the shock comes from real output (Fig 6.3.3) or from money supply (Fig 6.3.7) above. This would suggest that the money aggregate is responding to both the output and the price effect embodied in nominal output[36] hence the larger response.

Long run analysis

Examining the long run responses in Fig 6.3.9, all the four seem to level off to some constant value after ten quarters or so—implying that the system converges or is stable. This means that it is possible to obtain the values of the long run multipliers and the LRD test statistic. In interpreting the results, it is useful to remember however the nonintegrated property of the nominal GDP data.

Comparing the point estimates of the long run multipliers of real output (see previous analysis) and nominal output following a monetary shock[37], we see that the real output (DGDPR) multiplier is $139 million (or 15 per cent) while nominal output (DGDPN)

Fig 6.3.9 Long run responses

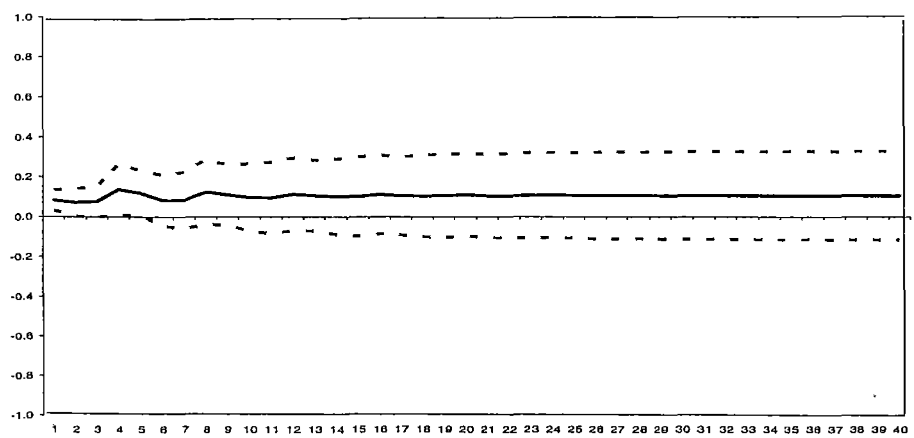


multiplier amounts to $147 million[38] (or 9 per cent). This implies that in relative terms, monetary shock has more impact on real GDP than on nominal GDP. This evidence is in

[36] Recall nominal output = PY (i.e. price x real GDP).
[37] Equivalent to about $420 million, i.e. equals to one standard deviation of money supply.
[38] See Table A6.3.13 (c).

contradiction to what we expect[39] but since nominal GDP is not integrated, this is plausible, i.e., because nominal GDP has no unit-root, it cannot sustain the impact of any shock—at least not as much as a series with a unit root. And as expected, the computed LRD test statistic of 0.11 is very close to zero—in fact, the 68 per cent confidence band encompasses

Fig 6.3.10 Computed LRD test statistic



the zero axis hence we cannot reject the hypothesis that LRD = 0. If nominal GDP had a unit root then we expect the LRD to be close to unity but in this instance, the LRD should be close to zero because nominal output has not undergone any 'permanent' change.

In summary we see from the impulse analysis that movement of money supply is countercyclical following a monetary shock but is procyclical when there is output shock. This pattern is also observed in the previous analysis when real GDP was used. With respect to the long run analysis, the result is consistent with the unit-root theory which stipulates that only integrated variables can sustain or propagate the impact of shocks, at least in the long run. This importance of integration is aptly phrased by Bullard (1999) when he said, "*The nonstationarity in economic variables was viewed as something of a headache for much of macroeconometrics. But in a remarkable turn of events, it actually was a boon to testing neutrality propositions*". Obviously our empirical test results have just demonstrated this '*remarkable turn of events*', i.e. a nonstationary variable is crucial for testing long run hypotheses otherwise the test will be not very useful because no 'permanent change' has occurred.

[39] According to the quantity theory the change in money is to be fully reflected in the change in nominal output in the long run, i.e. we expect a relatively higher response from nominal output.

6.3.4 Money M3 vs real GDP

The comparison of this model with the first model (in which money M1 is used), is important because of the uncertainty as to which of the monetary aggregates or instrument has greater impact on real activity. As Friedman (2000) says, *"...there was never a sound theoretical basis for knowing which measure of money was the right one to target (currency plus checking accounts only? currency plus all bank deposits? other combinations?), and even within any one country empirical evidence on which measure had the closest relationship to income and prices was often mixed"*. Some studies find that long run neutrality holds when narrow money measures (e.g. monetary base or M1) are used but not when broader money measures (e.g. M2 or M3) are used while others find the opposite[40]. This conflicting result is unfortunate because the issue is very important to central banks and to monetary policy makers in particular because it provides them with more specific policy aggregates or intermediate targets that they can manipulate in order to affect real output[41]. The evidence provided here is intended to shed more light on the issue—at least from the New Zealand context.

The testing and estimation procedure of the first two models is followed here as well.

Testing the lag length and cointegration

The estimated results of the unrestricted VAR incorporating real GDP and money M3 in first difference is shown in Table A6.3.14 in the appendix. The AIC, SBC and the adjusted LR tests all select the VAR of order 4. However, there was some serial correlation noted when 4 lags is used so 5 lags is used and the diagnostic tests results, shown in Table A6.3.17 and Table A6.3.19, show no evidence of serial correlation nor heteroscedasticity this time, i.e. the model specification with 5 lags seems adequate.

The cointegration test results are shown in Table A6.3.15 and both the maximum eigenvalue and the trace tests do not reject the null of no cointegration (i.e. r = 0). The SBC model selection criteria test also has the same result but the AIC test suggests r = 2 and the HQC test suggests r = 1. The 'no cointegration' conclusion is adopted because the Johansen

[40] Bullard (1999) reviews some of these studies.

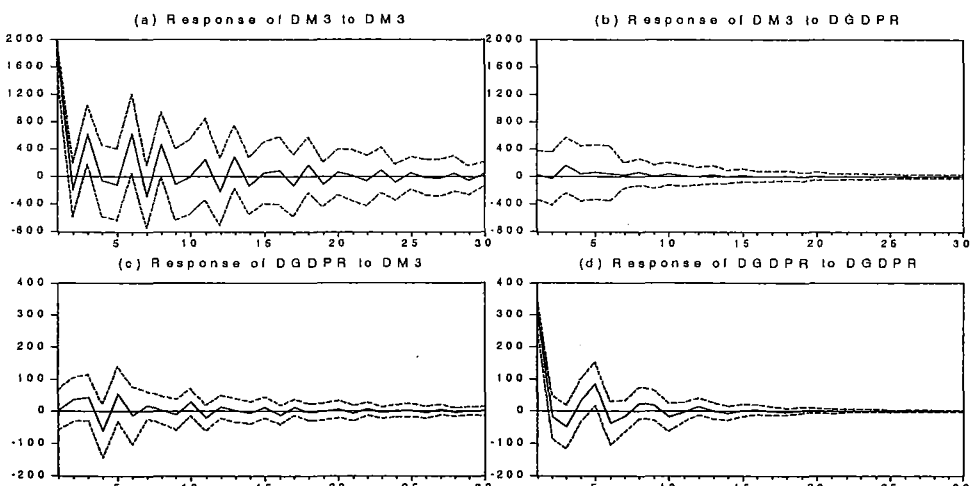
[41] Although many central banks these days focus more on inflation targeting, they are still very conscious of their monetary policy's impact on output.

tests are more accurate and more specific than the model selection criteria tests, therefore the model will be estimated as a straightforward VAR with 5 lags, 3 seasonal dummies and a constant.

Short run analysis

The impulse responses shown in Fig 6.3.11 do not decay quickly like the impulse responses of the first model incorporating real GDP and money M1. Generally when an impulse response behaves like this, it is likely the series concerned has a unit root or a 'near' unit root. However as reported in Table A6.2.1, money M3 is integrated of order one therefore in first-difference the variable should be stationary. In the literature variables behaving like this are said to have a 'long memory'.

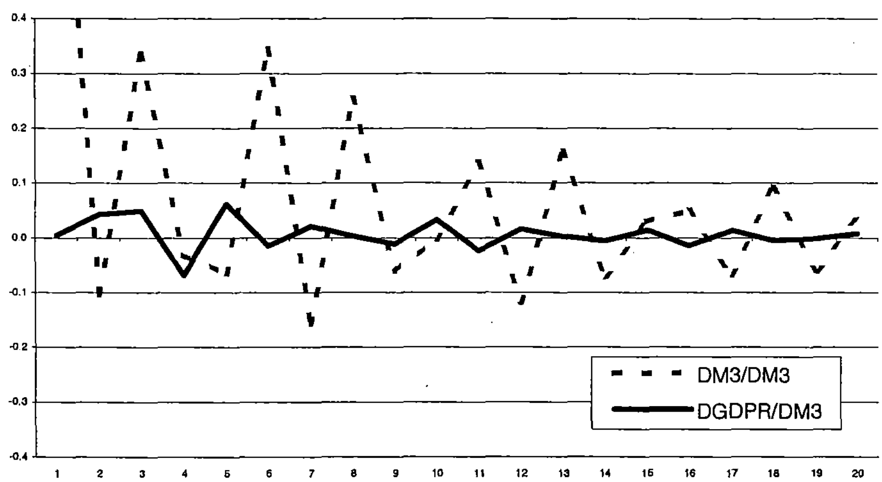
Fig 6.3.11 Impulse responses



Now to examine the impact of a monetary shock on real output and money supply, we see from Fig 6.3.11 that the latter fluctuates quite significantly whereas output response is more muted. Following monetary shock real output increased \$37 million (or 4 per cent) in the 2nd quarter, then \$42 million (5 per cent) in the 3rd quarter, but declined fairly dramatically by 7 per cent in the 4th quarter. In the 5th quarter, it increased by another 6 per cent. This is the largest increase of real output after monetary shock so we see that while the maximum response of real output to the M1 shock occurs in the 4th quarter (referring to the previous analysis), here it occurs in the 5th quarter. As to the magnitude of the responses, it is roughly the same, i.e. around 5-6 per cent. What this suggests is that the short run response of real output to monetary shock, whether it be money M1 shock or broader money M3 shock, is basically the same—around 5-6 per cent, but in terms of the lag-period, real output seems to respond slightly faster to changes in M1 than to changes in M3. This seems plausible given the more 'liquid' nature of M1 compared to M3, i.e. any increase in M1 can easily be translated to consumption or investment expenditure while the more illiquid M3 may take time to use for similar spending purposes.

Looking at Fig 6.3.12, the countercyclical pattern is also evident, in particular it is quite clear from the 5th quarter onward that when real GDP peaks, money M3 reaches its minimum point, and vice versa. This would be consistent with the responses in Fig 6.3.2.

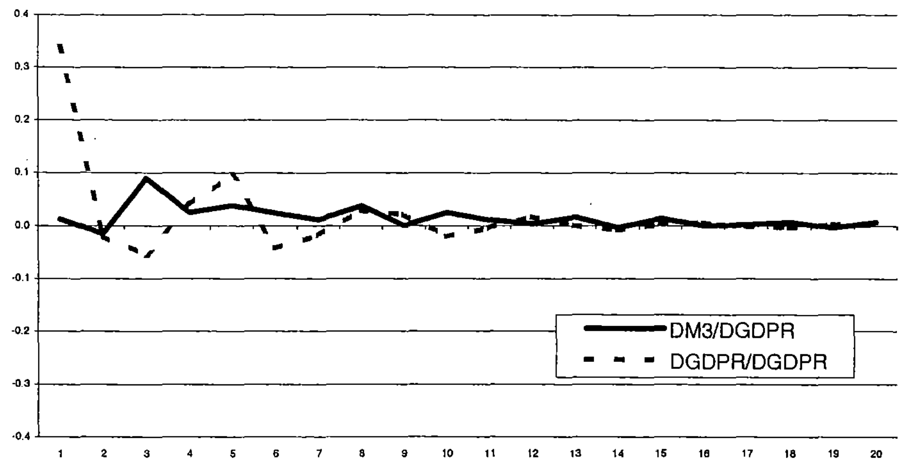
Fig 6.3.12 Impulse responses of real GDP and money M3 to money M3 shock



When there is output shock, the impulse responses of real output and money M3 are shown in Fig 6.3.13. This is the counterpart of Fig 6.3.3.

Following output shock the impulse response of money M3 is generally positive with the maximum response of 9 per cent observed in the 3rd quarter. The procyclical response that is observed when money M1 is used (see Fig 6.3.3) is no longer evident here. This would suggest that M1 is more endogenous than M3 in the sense that as output increases M1 increases, and when it decreases, so does M1. Furthermore, in terms of the response magnitude, the magnitude of 9 per cent observed here is much lower than the 17 per cent response observed for money M1 in the first analysis. This suggests that when real output

Fig 6.3.13 Impulse responses of real GDP and money M3 to real GDP shock



increase, there is more demand for money M1 than for the broader M3. This seems plausible given that for investment and consumption purposes the more 'liquid' form of money, such as M1, would be more suitable than the more 'illiquid' M3.

The magnitude and pattern of output response following a real shock is basically the same as in Fig 6.3.3.

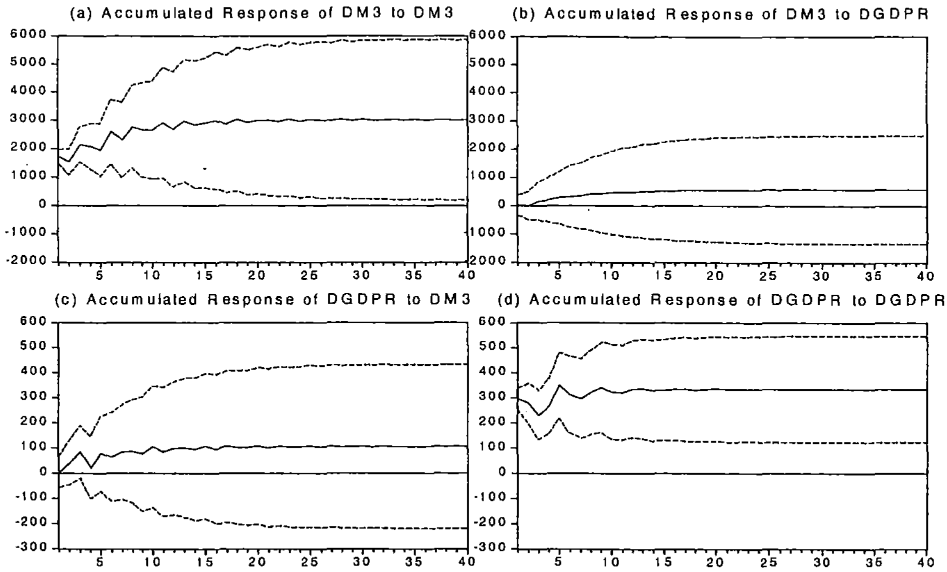
Long run analysis

Now with respect to the long run responses, all the graphs in Fig 6.3.14 level off after some time suggesting the model is stable. The point estimate of the long run multiplier of real GDP to a monetary shock[42] is \$106 million or 12 per cent (see Table A6.3.20). This implies that a one standard deviation shock to money M3 aggregate will cause real output to increase by 12 per cent. This is slightly lower than the long run response of output to money M1 shock of 15 per cent. This suggests that M1 has greater impact than M3 on real output.

As to the long run multiplier of money M3 with respect to output shock, the point estimate is \$565 million or 30 per cent (see Fig 6.3.14 (b) or Table A6.3.20). This positive point estimate is very different to the –\$10 million point estimate (almost zero in relative terms)

[42] Equivalent to \$1835 million or one standard deviation.

Fig 6.3.14 Long run responses

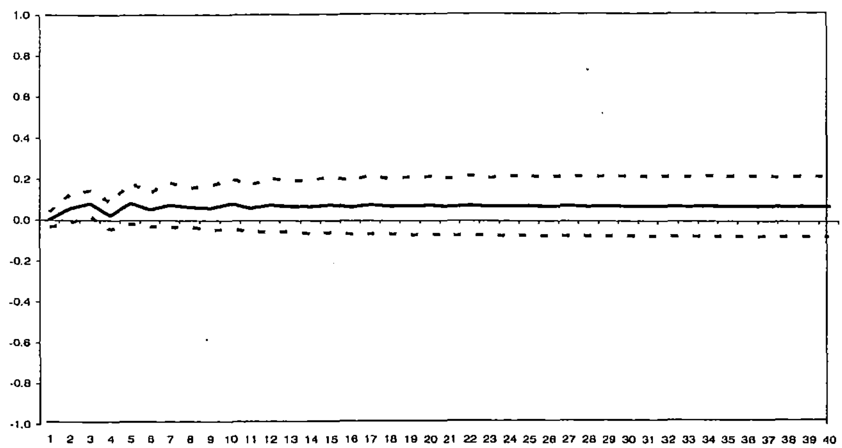


of money M1 long run multiplier in the previous analysis (see Table A6.3.7 and Fig 6.3.4c). What this means is that a permanent increase in real output will ultimately raise the level of money M3 permanently but not money M1, i.e. M3 seems to be more endogenous to output movements than M1[43]. This would seem to contradict our earlier impulse response analysis in which we concluded that M1 is more endogenous than M3. Fortunately this is not the case. What happens is that in the short run M1 is more responsive to output changes but not in the long run. M3, on the other hand, is permanently affected by a permanent increase in output. To rationalise this in the context of the quantity theory formula (MV = PY), an increase in output (Y) should be matched by an increase in money supply (M)—provided the velocity of money (V) is constant[44]. The behaviour of money M3 therefore seems to follow this theory but not M1. That is, money M1 long run response of almost zero means that its velocity must increase following a positive increase in output[45]. This seems to reflect the more 'fluid' or 'liquid' form of M1 in contrast to the more 'illiquid' M3. Another way of putting it, M1 acts more like a medium for transactions (a veil) whereas M3 acts more like a 'store of value'.

[43] The endogeneity of M3 is also reported by Serletis and King (1993) using the Granger-causality test.
[44] This assumes money is endogenous.
[45] Another possibility is for the price to go down following an increase in output but in most cases prices rise following output expansion (i.e. the short run Phillips curve) hence the velocity has to increase as well.

Examining now the LRD statistic, we see from Table A6.3.20 that the point estimate is 0.07. This is smaller than the LRD statistic computed for money M1 (of 0.12) suggesting

Fig 6.3.15 Computed LRD statistic



that money M1 aggregate has more influence on real output than M3 aggregate, at least in the long run. However, taking into account the confidence interval of 68 per cent, we cannot reject the null hypothesis that LRD = 0, i.e. we cannot reject the long run monetary neutrality proposition based on the evidence available.

So even if we use the broader measure of money, such as M3, we still cannot reject the long run neutrality hypothesis. This is in contrast to some results that reject long run neutrality when broader money is used[46]. And in the context of the question raised at the beginning of this analysis as to which monetary aggregate is likely to have more influence on real output, the evidence obviously points to the narrower monetary aggregate M1[47].

6.3.5 Money M1 versus Price

Estimation of this model is quite important because of the presumed one-to-one relationship between changes in money supply and changes in the price level as embodied in the quantity theory. As noted by Gale (1983, p. 85), *"In a steady state the price level and the money supply grow at the same proportionate rate, so by controlling the rate of growth of money supply the government can control the rate of inflation".* Furthermore, some

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[46] For example, Olekalns (1996) study using Australian data as well as the study by Coe and Nason (1999), as cited in Bullard (1999).

[47] This would seem to be consistent with Serletis and King (1993) finding that narrow money, however defined, causes real output while the broader aggregates reveal no causality to real income.

studies[48] have used inflation rate as a proxy for money growth rate when the latter is not available or when its order of integration is not greater than the real output order of integration[49]. So the basic question here is: Does empirical evidence support this equiproportional change in money supply and inflation? Also the question of whether or not money supply is endogenous is another contentious issue between the orthodox monetarists and the Post-Keynesians[50] with the latter advocating the endogeneity of money while the former supports the exogeneity idea. Empirical evidence from this analysis should therefore be useful not only to the neutrality proposition but should also provide useful insight as to which school of thought is being endorsed or validated by the New Zealand data. And in a more applied context, the information should also be useful to countries[51] that are primarily concerned with price stability for despite its long history and substantial evidence, the predicted association between money and inflation remains disputed (Dwyer and Hafer, 1999).

The CPI is used as measure of the price level and from Table A6.2.1, we see that it is nonstationary or has a unit root but becomes stationary upon first differencing, i.e. has order of integration of 1. Money M1 has also the same nonstationarity property therefore we expect both to undergo a 'permanent' change when they are 'shocked'. It should be emphasised here that CPI in first-difference (DCPI) is not exactly the same as the inflation rate, at least in this study because the data are not in logarithmic value—this is unlike most studies that use logarithmic values of the price indices which makes the first difference a good approximation of the growth rate[52]. Nevertheless the effect or the response of price level in first-difference (DCPI) should be fairly similar to that of the inflation rate (INF).

Order of the VAR and model specification

Table A6.3.21 provides results of the selection criteria tests. AIC, SBC and the LR test results all select VAR of order 4. However using 4 lags produces serial correlation so the

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48 Such as Rapach (1999).

49 That is, to test for superneutrality, money aggregate should be integrated of order 2 if real output is integrated of order 1.

50 Discussed in Snowdon et al. (1994, p. 373).

51 For example, Canada, New Zealand, United Kingdom (see Dalziel, 2001).

52 As pointed out by Thomas (1993, p. 154), "*the approximation* [i.e. $\log Y_t - \log Y_{t-1} \approx \frac{Y_t - Y_{t-1}}{Y_{t-1}}$] *will hold provided growth rates are small so that* $Y_t \approx Y_{t-1}$.

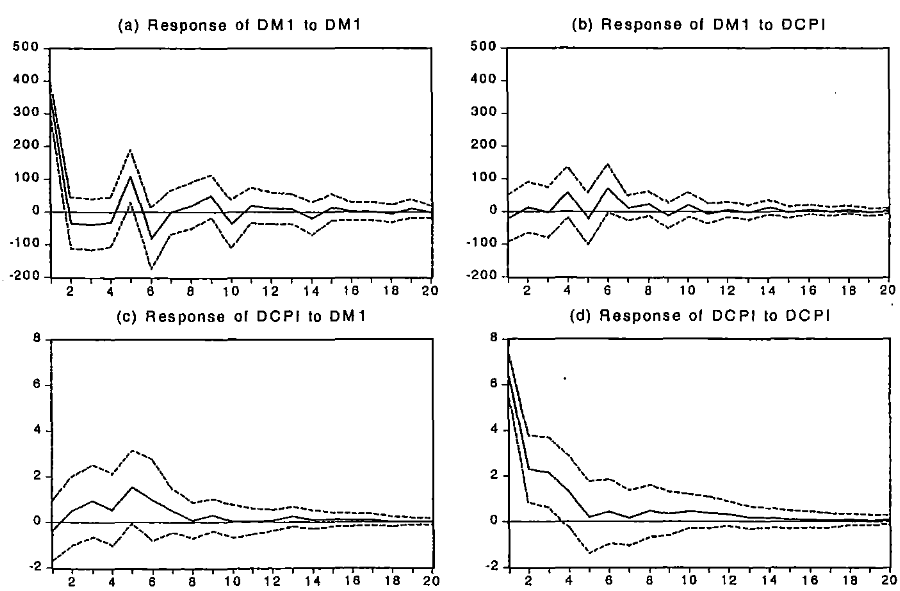
lag is increased to 5 quarters but still the equations show some evidence of autocorrelation so a time trend is added. The diagnostic test results show no more evidence of autocorrelation but there is some small evidence of heteroscedasticity in the price equation (see Table A6.3.26). Obviously the price variable has undergone major structural changes and so we tried adding the dummy variable to account for the introduction of the GST but while this solves the heteroscedasticity problem, it introduces serious autocorrelation so we decided not to include the GST dummy.

The cointegration test results are presented in Table A6.3.22 indicating that neither the maximum eigenvalue nor the trace test reject null hypothesis of no cointegration. The model selection criteria tests, on the other hand, give mixed results—both the AIC and the HQC suggest one cointegration relationship but the AIC concurs with the Johansen's test results. Because there is no overwhelming evidence of cointegration, the final model specification is the straightforward VAR with 5 lags, seasonal dummies, a time trend and a constant. The estimation results are shown in Table A6.3.23 and Table A6.3.26.

Short run analysis

From the impulse response graph (Fig 6.3.16) below we see quite distinct and interesting patterns. First, whilst money supply M1 responses tend to show alternating positive and

Fig 6.3.16 Impulse Responses

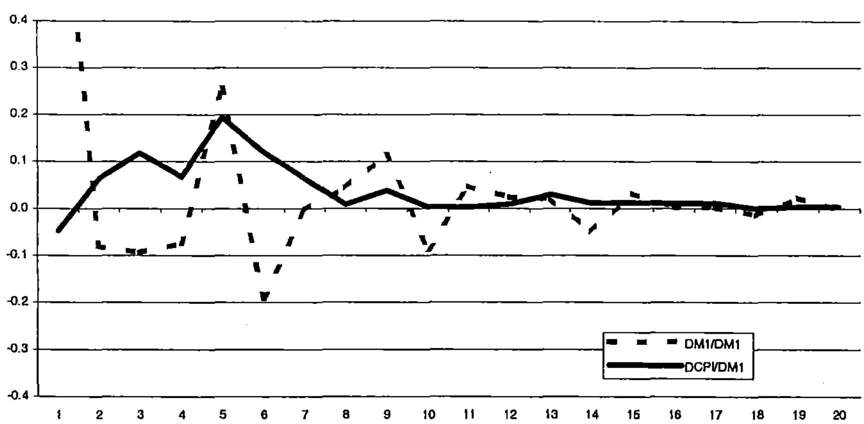


negative values, responses of the price variable to either shock are practically all positive. This suggests some kind of serial correlation behavior yet according to the Langrange Multipler and the F tests (see Table A6.3.26), the price equation is not serially correlated. One interpretation of this is that prices are 'sticky', i.e. do not change relatively as fast as the other variables, at least in the short term.

To examine closer the contemporaneous movements of both price and money supply following an exogenous shock we look at Fig 6.3.17 and Fig 6.3.18.

Following monetary shock, price increases for almost eight quarters (two years). The maximum response of 19 per cent (or 1.5 percentage point) occurs however in the 5th quarter—the same time as money supply peaks. In the 9th quarter the two variables both peak again though the magnitudes are quite small this time. What the evidence here shows

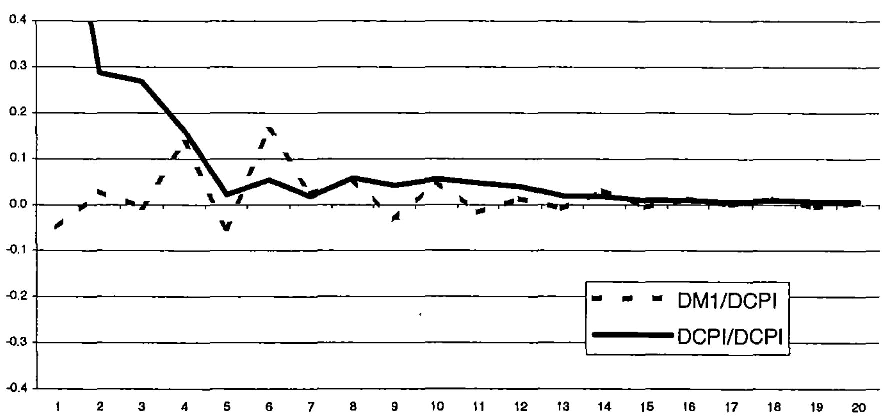
Fig 6.3.17 Impulse responses of price and money M1
to money M1 shock



is that price will significantly increase and remain positive for several quarters following a money supply increase. Furthermore, any other increase in money supply following the initial shock will be simultaneously matched by further price increase—as noted in the 5th and 9th quarters. This observation concurs well with monetarist's contention that inflation is a monetary phenomenon, i.e. when money supply increases, price will also increase. Another important conclusion is that price is 'sticky'. This is because price response to monetary shock remains positive for almost two years—despite the contemporaneous negative values of money supply in the subsequent quarters, particularly in the 3rd and 6th quarters.

Now let us consider what happens when there is price shock. The responses of the two variables are shown in Fig 6.3.18. The response of money supply to price shock is generally positive and the two peak responses (14 per cent and 16 per cent) occur in the 4th and 6th quarters implying that it takes a year or more for money supply to respond. This positive response of money supply to price increase is consistent with the Post-Keynesian assumption that money is endogenous (see Snowdon et al., 1994, p. 374) however the delayed response would suggest that there is some 'friction' in the money or credit market—again in accordance with the Keynesian general view of the economy[53].

Fig 6.3.18 Impulse responses of money M1 and price to price shock



To compare the impact of money on output (refer to the first analysis) and on inflation, it is interesting to note that real output shows its maximum response in the 4th quarter while price peak response is observed in the 6th quarter. So if we assume monetary policy acts through money supply M1, then the impact of monetary policy is much 'slower' on price level than on real output[54]. Another interesting difference is the relatively small response of real output (around 5 per cent) to monetary shock compared to price response of almost 20 per cent. This in a way provides justification for monetary policies that primarily focus on

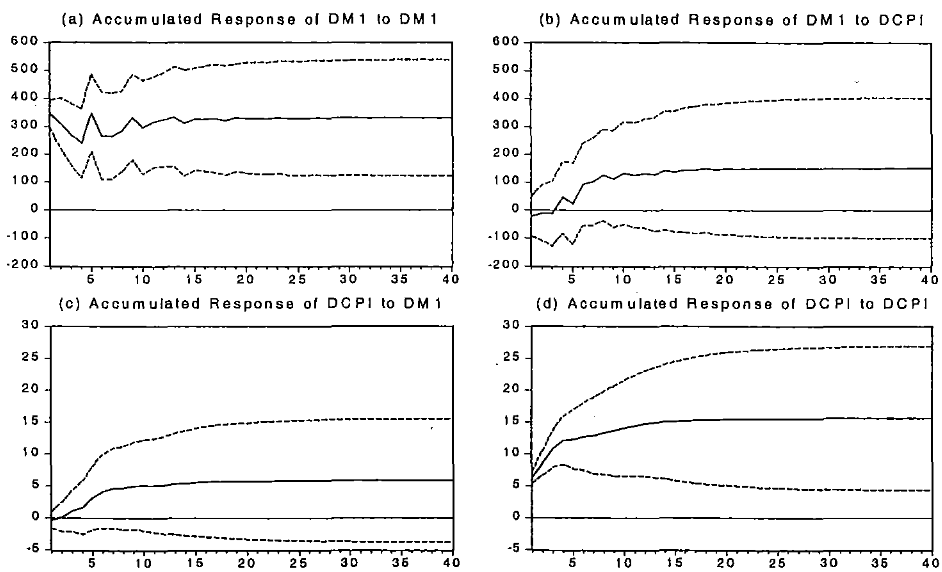
[53] In contrast the Classicals always maintain a 'market clearing' assumption.
[54] This result is somewhat consistent with Clarida et al. (1999) finding that monetary policy impact on inflation takes longer period of time to have the intended effect: they put six to nine months to reach output and over a year to reach inflation.

inflation rather than on output: firstly, because the time-lag between monetary shock and the impact on inflation is more extended and secondly, because monetary impact on real output is relatively small.

Long run analysis

The long run responses with 95 per cent confidence interval are shown in Fig 6.3.19 below. In spite of the inclusion of the zero axis within the 95 per cent confidence band in graphs (b) and (c), the responses are generally significant. In fact if we use the 68 per cent confidence, which some studies have used[55], all the responses would have been significantly different from zero implying all the variables have undergone significant

Fig 6.3.19 Long run responses

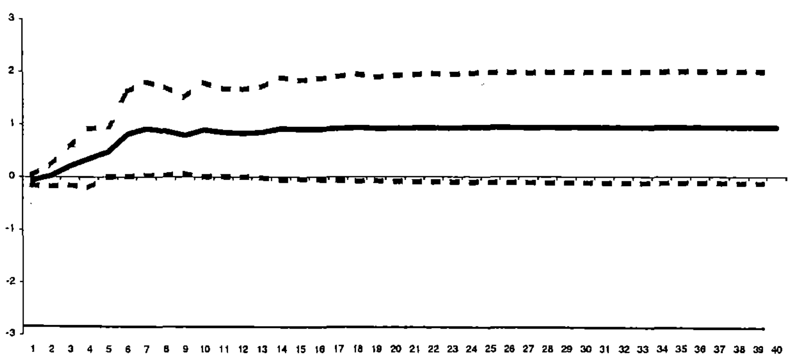


'permanent' changes following exogenous disturbances. In other words, a permanent change in money supply will cause price level to increase significantly, and vice versa. This is an interesting revelation because it shows that money supply can both be exogenous in the sense that it causes price to increase and also endogenous to price movements, i.e. it seems to accommodate both the Classicals view and the Post-Keynesians stance. It is also useful to note that it takes generally less than ten quarters (i.e. just over two years), before the new equilibrium levels are reached.

[55] For instance, in their paper on New Zealand business cycle, Buckle et al. (2002, p. 20) said, *"As is commonplace in the VAR literature, sixty-eight per cent confidence bands have been estimated for the impulse response functions using the Monte Carlo bootstrapping approach of Runkle (19879".*

For the long run neutrality test we need to examine the LRD test statistic. According to Table A6.3.27 (c), the LRD point estimate is 0.93. This is fairly close to one, in fact, the 68 per cent confidence band encompasses the unit horizontal axis 'comfortably'—but not the zero axis (see Fig 6.3.20) therefore we do not reject the hypothesis that LRD = 1, but we do reject that LRD = 0. This provides further evidence of the long run monetary neutrality proposition, i.e. changes in money supply is fully reflected in price level increase leaving real output unchanged.

Fig 6.3.20 Computed LRD test statistic



So in answering the question posed at the beginning of this bivariate analysis as to whether price responds equiproportionally to increases in money supply, the answer obviously would be yes[56]. It is also important to note the evidence of price 'stickiness' from the short run analysis—an assumption often made by the New-Keynesians. As to the lag-period before the 'peak' effect of money increase is noted on inflation the analysis indicates five quarters (i.e. just over a year). Another useful insight is the fact that money responds positively to price increase—both in the short and long run, i.e. this would support the Post-Keynesian view that money is endogenous to price movements. Finally the evidence from the LRD neutrality test provides further support to the long run monetary neutrality hypothesis.

[56] This finding is consistent with Dwyer and Hafer (1999) contention that *"inflation and money growth are related over time and those who asserted otherwise are misguided at best"*.

6.3.6 Inflation rate and Interest rate (Fisher's relationship)

Although real output is not used here, the proposition is basically another version of the long run neutrality classical hypothesis[57]. This is known as Fisher's long run relationship between inflation rate and interest rate and in addition to its close relationship to monetary neutrality, it is also important in the context of this study because the interest rate has become, in recent years, the primary tool of central banks in controlling inflation and influencing economic activity[58]. In fact, in the monetary transmission literature, interest rate is one of the key variables, if not the most important variable. This is easily attested by the consistent use of the interest rate in central bank monetary policy models as well as in the New Keynesian models[59].

Fisher's relationship says that *a permanent change in inflation rate has no long run effect on the real interest rate.* However in this study, we will use nominal interest rate so the hypothesis changes to: *a permanent change in inflation rate will cause an equiproportional change in nominal interest rate.*

From Table A6.2.1, we see that the interest rate is integrated of order one while the inflation rate is stationary. This may pose some problem in estimation because we need the inflation rate to be nonstationary (i.e. have a unit-root) otherwise it would not be able to 'sustain' the permanent change required for testing the long run hypothesis. Despite this problem, the model will still be estimated with the variables in first-difference keeping in mind the stationarity property of inflation rate, especially when interpreting the results.

Order of the VAR

The results of the first unrestricted VAR model estimated with 12 lags incorporating interest rate and inflation rate, both in first-difference, is presented in Table A6.3.28. The model selection tests give mixed results, for example, AIC and the LR tests choose lag of 4 while SBC chooses lag of 1. Lag of 4 is chosen so that any seasonal effect would be

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[57] As Blanchard (1997, p. 386) points out, *"The second type of evidence is the relationship between the nominal interest rate and inflation rate over time in one country. Again, the Fisher hypothesis does not suggest that the two should move together from year to year. But it does suggest that the long-run movements in inflation should eventually be reflected in similar movements in the nominal interest rate".*

[58] Arestis and Sawyer (2002) referred to this as the 'new' approach to monetary policy.

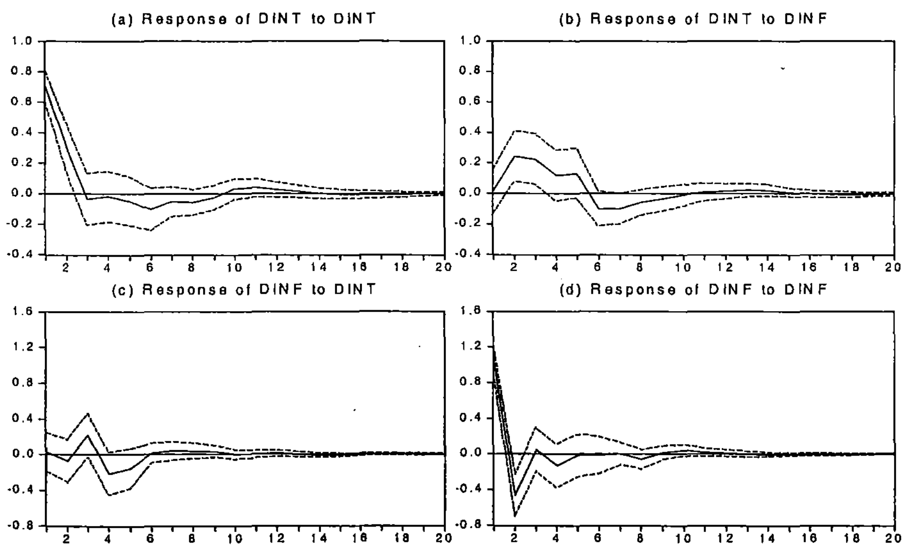
[59] There are however some who still argue that money aggregate has important role in influencing real output (or in monetary policy), such as Favara and Giordani (2002), Leeper and Roush (2003), Peterson (1996), among others.

'smoothed out' and also to minimize the potential effects of serial correlation. The model is reestimated with 4 lags and a constant (no seasonal dummies included this time) and the diagnostic test results in Table A6.3.30 and Table A6.3.32 show a generally adequate specification apart from a small sign of heteroscedasticity in the inflation rate equation. There is no cointegration test because inflation rate is not integrated.

Short run analysis

The impulse responses of interest rate and inflation rate to exogenous shocks are shown in Fig 6.3.21. All the four responses seem to die out quite fast suggesting the variables in first difference are stationary—which is of course expected given the variables are already in rates.

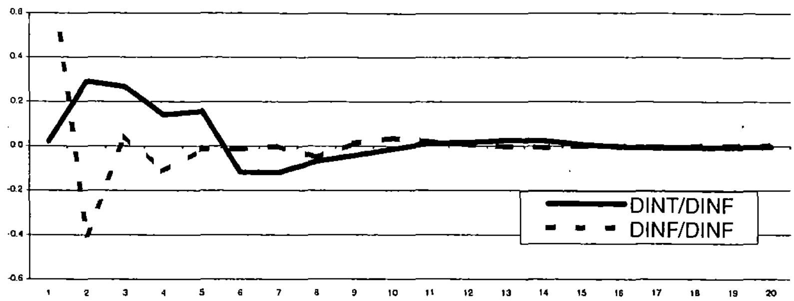
Fig 6.3.21 Impulse Responses



Since the Fisher hypothesis refers to the impact of the change in inflation rate on the interest rate, we will examine first the responses following an inflation rate shock. These are shown in Fig 6.3.22.

We see from Fig 6.3.22 that after an inflation rate shock the interest rate increased and remained positive for five straight quarters. It peaked in the 2nd quarter at 29 per cent (or 0.24 percentage point) while inflation rate reached its minimum of 40 per cent (or 0.46 percentage point) below equilibrium. So whilst interest rate displays positive responses in the first couple of quarters, inflation rate tends to be negative or zero in this period. This is the sort of contemporaneous movements expected between the two variables, i.e. as interest

Fig 6.3.22 Impulse responses of interest rate and inflation rate to inflation rate shock

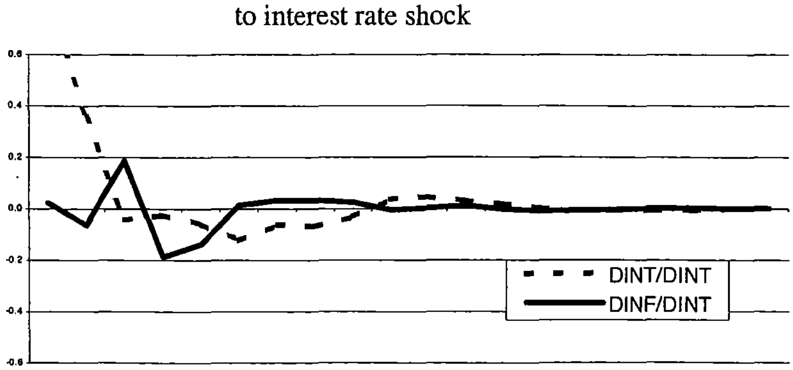


rate increased, inflation rate should decline. Assuming the interest rate movements reflects the monetary policy response to high inflation, then from this analysis it is clear that the impact of monetary tightening on inflation occurs fairly rapidly, i.e. within the second quarter. The sustained positive response of interest rate certainly holds down inflation as shown from the negative or zero response of inflation rate. Given New Zealand's commitment to price stability this observation seems quite plausible.

Now let us examine the contemporaneous movements of the inflation rate and interest rate following an interest rate shock. The responses are shown in Fig 6.3.23.

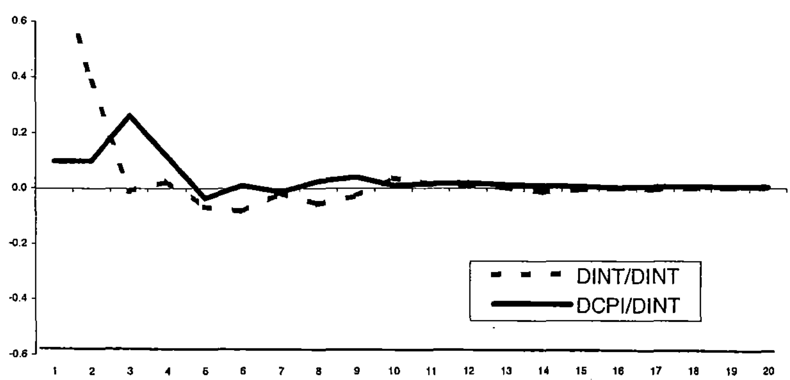
From Fig 6.3.23 we see that following the interest rate shock, the inflation rate does not respond until the 3rd quarter when it increased sharply by 19 per cent (or 0.22 percentage point). In the 4th quarter it declined by the same amount and remained negative in the 5th quarter as well. In the 6th quarter, it returned to the equilibrium position.

Fig 6.3.23 Impulse responses of interest rate and inflation rate to interest rate shock



What is interesting here is the positive response[60] noted in the 3rd quarter after the initial interest rate shock. This is an empirical 'anomaly' that many researchers using the VAR framework have observed and have accordingly dubbed –the 'price puzzle'. However the claim is that this positive response persists for several quarters, for example Giordani (2001a), says, *"the response was positive for many quarters"*, yet as observed here, this is not the case—i.e. it is observed only in the 3rd quarter. Mankiw (2000) talks about the delayed and gradual response of inflation to monetary policy shock. It is interesting to note though that when price in first-difference (DCPI) is used instead of the change in inflation rate (DINF), Giordani's observation of the persistence positive response is noted (see Fig 6.3.24 below).

Fig 6.3.24 Impulse responses of price (DCPI) and interest rate (DINT) to interest rate (DINT) shock



This shows that when price in first-difference (DCPI) is used, the 'price puzzle' becomes very obvious. This would imply then that previous studies must have used price in first-difference rather than inflation rate in first-difference[61].

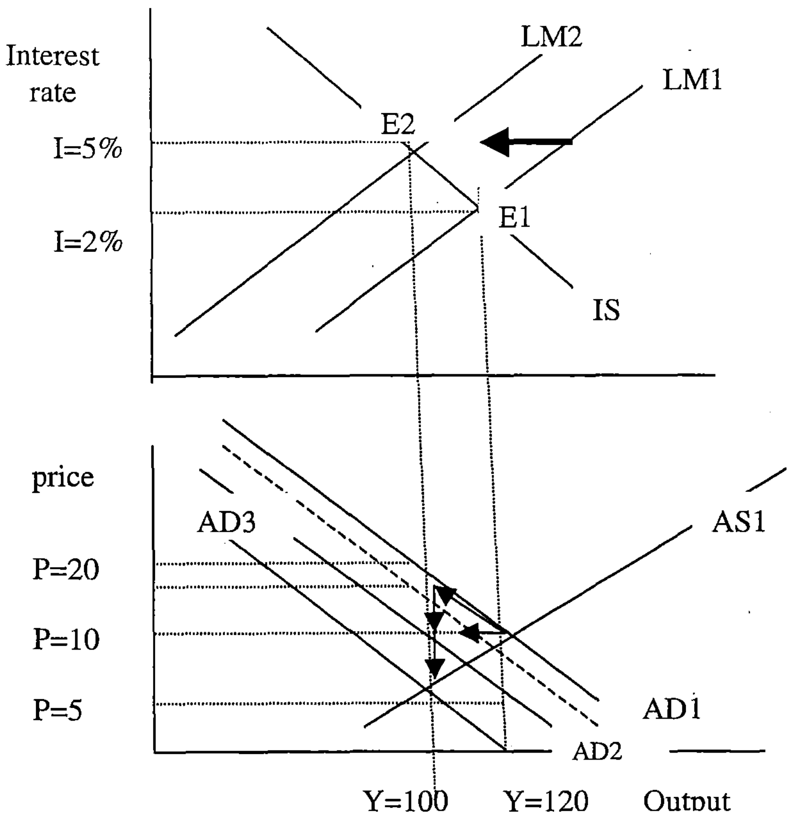
But regardless of whether DCPI or DINF is used, the positive response noted is worth considering. Several studies theorize on variable omission as the cause of the so-called 'price puzzle' and consequently include other variables, such as commodity price or monetary aggregate, to correct it. Giordani (2001a), on the other hand, argues that the

[60] Kuszczak and Murray (1987) also noted the positive relationship between inflation rate and interest rate and suggested a Fisher's effect explanation or a 'cost-push' effect known as the 'Patman effect'.

[61] This may have been caused by the use of logarithmic values which means the price level in first-difference is equated to inflation rate—this is not done here, i.e. in this study price level in first difference (DCPI) is not the same as inflation rate (INF).

inclusion of output gap in the model is the proper way of eliminating it—at least this is consistent with theory (as he puts it). Leeper and Rousch (2003) insisted that adding the monetary aggregate to the model would not only eliminate the 'price puzzle' but also the 'liquidity puzzle'. In spite of these arguments, this study suggests two explanations: one is to do with the contemporaneous movement of the interest rate following the initial shock, and the other is to be found in the IS-LM framework. In the first case, the dramatic decline in the interest rate following the initial shock (see Fig 6.3.23) would surely prompt an opposite response from price, which in this instance, is to increase. That is, as interest rate declines (or becomes very low) one would expect more people (and businesses) to make loans thus driving up the prices—hence the price increase or 'puzzle' observed. With respect to the IS-LM framework explanation, this is illustrated in Fig 6.3.25 (the numbers are just for illustrative purposes).

Fig 6.3.25 Demonstrating price increase following interest rate shock



From Fig 6.3.25 an interest rate shock (say following monetary policy tightening) would be represented by a shift of the LM curve to the left (see top figure). According to the aggregate demand theory[62] this should cause the aggregate demand curve AD1 to shift to the left (AD2) in order to maintain the price (of say 10). Now suppose instead of an instantaneous shift to AD2, the aggregate demand curve move slowly, say due to friction in the economy. In this case the price will initially rise (say to 20) as consumption moves along the initial demand curve (AD1) to the left. Then as the aggregate demand schedule shifts to the left, i.e. to AD2, price starts to decline until it reaches the original price of 10. However if the original aggregate supply AS1 remains as before, then there is tendency for the aggregate demand schedule to move further to the left (to AD3) while price keeps falling below the initial price of 10. This would then explain how price tends to rise initially following monetary tightening and then after some time it starts to decline, sometimes going even below the original price level. Whether the assumption of the slow adjustment of the aggregate demand curve following monetary shock is plausible or not is a question for empirical testing however it is important to note here the potential use of the IS-LM framework in explaining the 'price-puzzle'.

The long run analysis, which is more appropriate to the Fisher hypothesis, is carried out next.

Long run analysis

The long run responses shown in Fig 6.3.26 are fairly significant apart from the inflation rate response—but even this is significantly different from zero if we use the more standard 68 per cent confidence interval.

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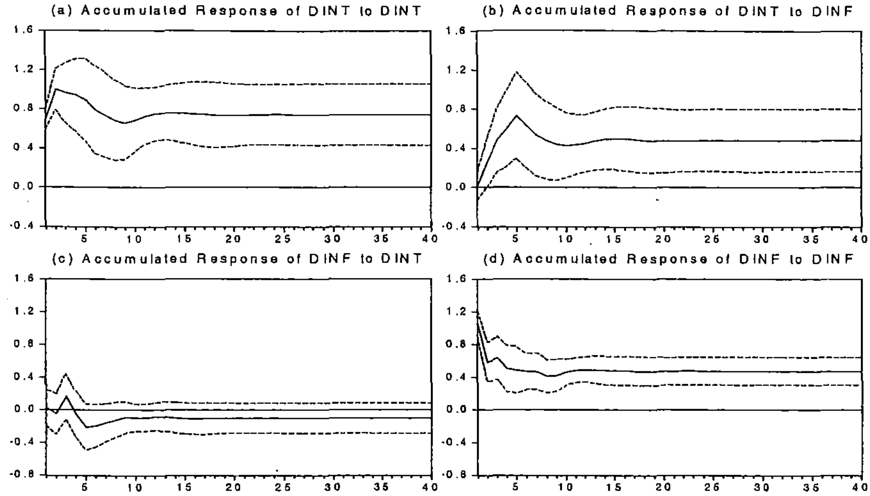
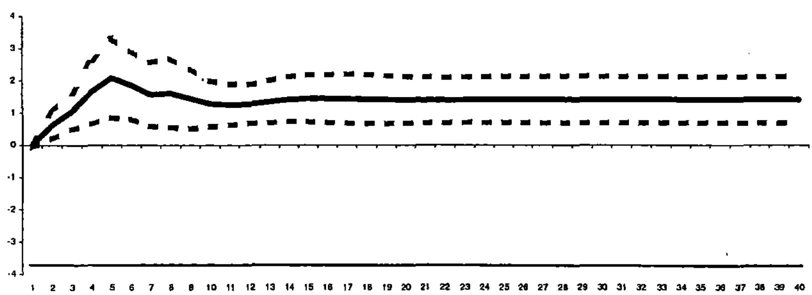
[62] Which says that the aggregate demand curve is drawn holding "other things equal" (see, for example, Mankiw, 1998, p. 411 or Hillier, 1991, p. 80-85).

Fig 6.3.26 Long Run Responses



Looking at Fig 6.2.26 (b) we see that the long run response of interest rate to positive permanent change in inflation rate is positive and significantly different from zero at the 5 per cent significance level. The point estimate is 0.48 percentage point (see Table A6.3.33). Interestingly, the inflation rate long run response, to the same inflation shock, is also 0.48 percentage point. Obviously this implies a one-to-one relationship, which will perfectly match Fisher's hypothesis, but this is not quite correct because we need to normalize the units by dividing the long run multipliers by their respective standard deviation. The resulting value of the division is in fact the LRD test statistic shown in Fig 6.3.27 below.

Fig 6.3.27 Computed LRD test statistic



The point estimate of the LRD test statistic is 1.4 (see Table A6.3.33). This is slightly more than the unit value we require for the Fisher hypothesis to hold, however if we look at the 68 per cent confidence band in Fig 6.3.27, the unit horizontal line is obviously within this band hence we cannot reject the hypothesis that LRD = 1. In other words, we do not reject the Fisher hypothesis that eventually change in inflation rate will get all reflected in the increase in nominal interest rate. It is useful to note also the time before the LRD levels off because this would indicate the period for the effect of inflation change to work itself completely into nominal interest rate. According to the above figure, the period would be just over ten quarters (i.e. over two years).

Looking at the inflation rate response to the interest rate shock in part (c) we note the positive response in the 3rd quarter followed by a negative response of 0.1 percentage point (or 8.6 per cent). This shows that a one standard deviation shock (roughly 0.84 percentage point) in the interest rate will cause a permanent decline in the inflation rate by 0.1 percentage point. Putting it differently, a percentage point increase in the interest rate will cause inflation rate to decline permanently by 0.12 percentage point.

Summarizing the evidence, we see that a permanent increase in inflation rate will cause nominal interest rate to increase on a one-to-one basis in the long run—in line with the Fisher hypothesis[63]. However we see that the point estimate of the relationship is slightly more than unity but if we take into account the 68 per cent confidence interval then we cannot reject that it is equal to one. The evidence also points to a long period of time before the effect of inflation rate shock is entirely reflected in interest rate (over two years)—however the period noted here is much shorter than the 'couple of decades' that Milton Friedman speculated[64]. On the impact of interest rate on inflation rate, we also observed the price 'puzzle' that many researchers have encountered. However when we use the inflation rate variable in first-difference (DINF), the puzzle is restricted only to the 3rd quarter, i.e. not the extended period that Giordani (2001a) points out. Only when we use price in first-difference (DCPI) that we see the same extended positive response following interest rate tightening. As to the reason for the positive response of price following an interest rate increase (i.e. the price puzzle), we offer two explanations that are different to previous explanations. In brief we suggest that the price increase is not really a puzzle, rather it is 'explainable' on the basis of the contemporaneous movements of the variables following the initial shock and on the basis of the IS-LM framework.

[63] This result is different to King and Watson (1999) finding that show nominal interest rates not adjusting fully to inflation shock. Also Rapach (1999) result does not support the Fisher's relationship, i.e. a permanent increase in inflation rate lowers the long run real interest rate for the 14 countries he studied.

[64] As cited in Blanchard (1997, p. 349)

6.3.7 Inflation vs real GDP (superneutrality test)

Here the change in the growth rate of money is important, i.e., the hypothesis states that the change in the money growth rate has no effect on real output in the long run. This means that to test superneutrality of money, the order of integration of the money aggregate should be greater than that of real GDP. However, from the unit root test results[65], we see that both money aggregates, M1 and M3, are integrated of order 1—the same as that of real GDP. In view of this, we cannot use the actual money growth rate here to test for monetary superneutrality using Fish and Seater (1993) LRD test framework. However, in line with most past studies on superneutrality[66], we will use the inflation rate instead. Besides, we have seen from our previous analysis that the money aggregate is positively correlated with inflation rate—hence there is basis for using inflation rate here.

It may be useful at this stage to say that the current empirical findings of the superneutrality tests are fairly mixed—i.e. some studies find that the long run response of output to inflation shock is positive while others find it to be negative. And while these may be incompatible with the classical notion of superneutrality, there are some theoretical models[67] that do support either result, and as Rapach (1999) argues, *"Given the ample cause to question LRSN[68] on theoretical grounds, it is important to evaluate its empirical relevance"*. The following analysis, needless to say, has the same objective—i.e., evaluating the empirical relevance of the long run superneutrality hypothesis.

Another interesting aspect of this particular model is that the relationship involved is in fact the famous Phillips relationship between output[69] and inflation rate. As pointed out in Snowdon et al.(1994, p.146), *"The Phillips curve is concerned with the controversy over the relationship between inflation and unemployment and is one of the most famous relationships in macroeconomics"*. Consequently the importance of the empirical results obtained from this analysis is not confined only to the classical superneutrality proposition

[65] See Table A6.2.1.

[66] Such as Bullard and Keating (1995) and Rapach (1999).

[67] See, for example, Patinkin (1989).

[68] Stands for 'long run superneutrality'.

[69] In the literature 'unemployment' and 'real output' are interchangeably used, especially when referring to the Phillips curve. An interesting articulation of the tradeoff between inflation and unemployment is provided in Mankiw (2000).

but also extends to one of the most debated macroeconomic issues—namely, the Phillips relationship.

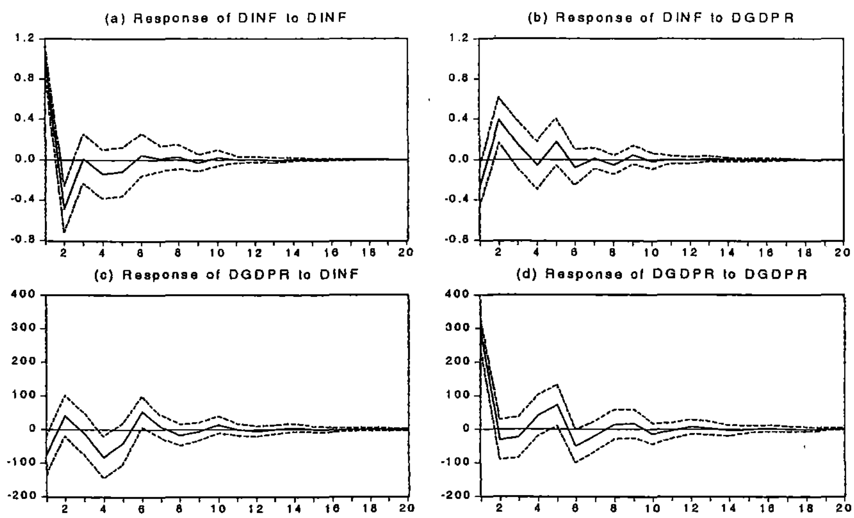
Selecting the order of the VAR

From Table A6.3.34 all the model criteria selection tests select VAR of order 4. So the VAR model incorporating the change in the inflation rate (DINF) and real GDP (DGDPR) is reestimated with four lags, a constant, and seasonal dummies. The results are shown in Table A6.3.35 and Table A6.3.37. There is no evidence of serial correlation or heteroscedasticity in the model. There is no cointegration test because by definition[70] the order of integration of the money aggregate should be greater than real GDP's order of integration.

Short run analysis

Looking at the impulse responses in Fig 6.3.28 below we see that the response of real output to an inflation shock (part c) is predominantly negative, while the inflation rate response to an output shock (part b) is predominantly positive. Following a real shock, the

Fig 6.3.28 Impulse Responses



inflation rate showed a sharp increase of 0.4 percentage point (or 34 per cent) in the 2nd quarter. This positive response is consistent with the aggregate supply curve formulation where inflation is usually a positive function of output. As to the negative output response

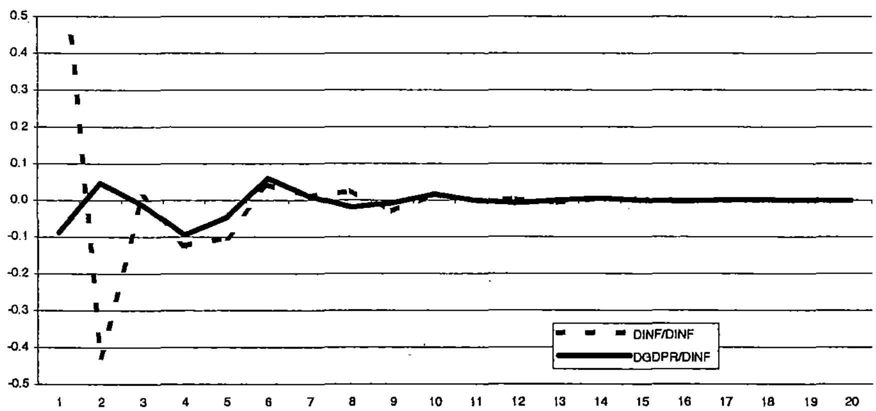
[70] Refers to the definition of 'long run superneutrality of money'.

following inflation shock, there may be several reasons but as explained by Friedman[71], the high rate of inflation creates uncertainty and reduces market efficiency leading up to higher unemployment (i.e. lower output).

Having described the general response of inflation rate and output to exogenous shocks, we will now examine closer the contemporaneous movements of the two variables. These are shown in Fig 6.3.29 and Fig 6.3.30.

From Fig 6.3.29 it is interesting to note that inflation rate dramatically declined by 42 per cent in the 2nd quarter after the shock. This significant decline is matched by a small increase in output of 5 per cent (or $41million) but then as the inflation rate returns to

Fig 6.3.29 Impulse responses of real GDP and inflation rate to inflation rate shock



equilibrium in the 3rd quarter, output shows a declining trend reaching its minimum of -$83 million (or 9 per cent) in the 4th quarter[72]. This would seem to be consistent with Kuszczak and Murray (1987) result that show output decreases in response to higher prices and interest rates after two to three quarters. After the 4th quarter, the two variables seem to move together. This demonstrates clearly the procyclical nature of inflation rate—at least after the initial effect of the exogenous shock has worn off. That is, under normal circumstances inflation tends to move with output—the so-called short-run Phillips curve.

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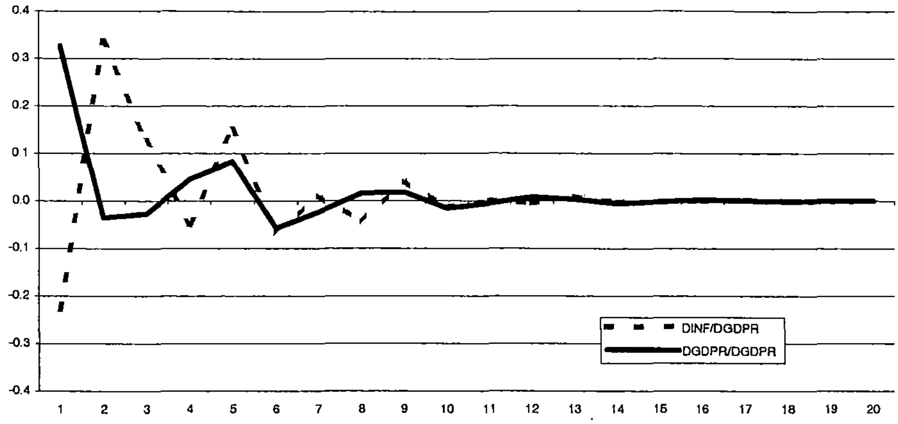
[71] As cited in Snowdon el at. (1994, p. 157): note however that Friedman actually uses the term 'positive relationship' because he was referring to the 'unemployment rate'.

[72] See Table A6.3.39.

Fig 6.3.30 Impulse responses of real GDP and inflation rate to real GDP shock



According to Fig 6.3.30, in the 2nd quarter following an output shock the inflation rate reached its maximum response of 34 per cent (or 0.39 percentage point) while output flattens out at 4 per cent (or $31 million below equilibrium). In the 4th quarter, output starts to increase and in the 5th quarter it reached its maximum of 8 per cent or $72 million—the same time inflation rate peaks for the second time. So here we see the procyclical nature of inflation again, i.e. moving in the same direction as output.

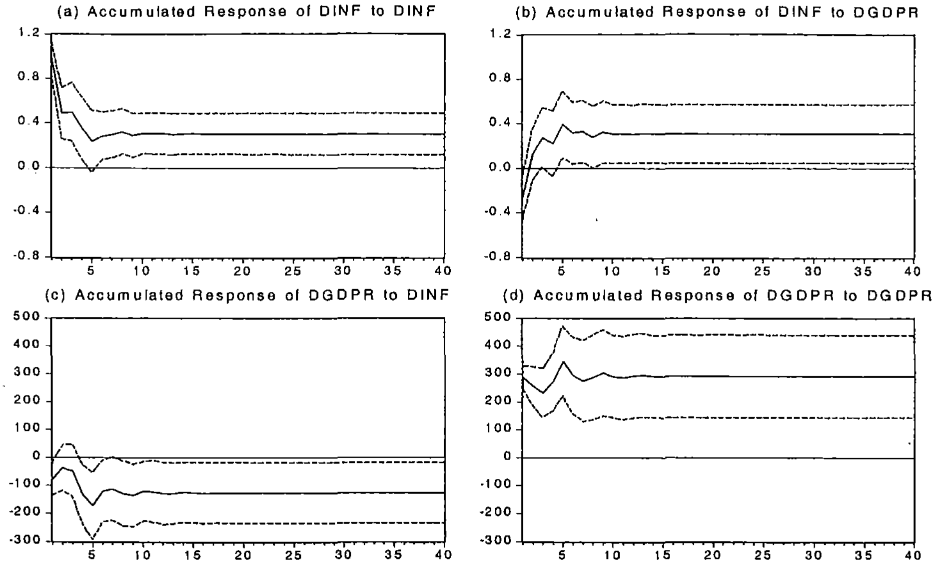
To summarise the short run results, real output declines by 9 per cent (or $83 million) four quarters after the inflation rate shock occurs. This would suggest that high inflation rate has an adverse impact on output. In contrast, the inflation rate responds positively (by 34 per cent) and more quickly (i.e. in the 2nd quarter) to output shock. This evidence and the observation that inflation seems to be procyclical support the short run Phillips curve which essentially predicts a positive correlation between output increase and inflation rate.

Long run analysis

Now turning to the long run responses (Fig 6.3.31), we see all the long run responses are significantly different from zero at the 95 per cent confidence interval. This implies that the variables have undergone significant permanent change after being subjected to exogenous shocks. The point estimate of the output long run multiplier due to an inflation rate shock is -$126 million[73] or 14 per cent (see part c). This means that for one standard deviation (or

[73] See Table A6.3.39.

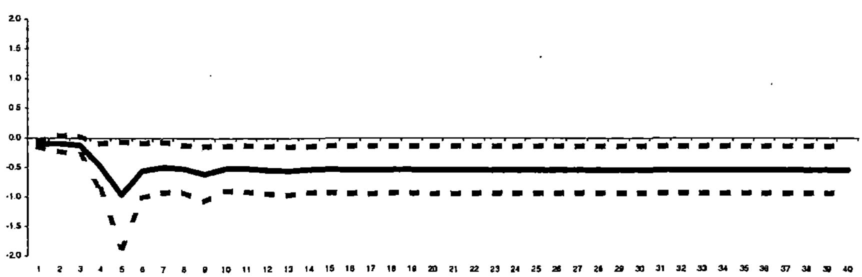
Fig 6.3.31 Long run responses



1.2 percentage point) increase in inflation rate, we expect real output to decline by \$126 million. The other important long run multiplier is that of the inflation rate with respect to the output shock. According to Fig 6.3.31 and Table A6.3.39, the point estimate is 0.3 percentage point (or 27 per cent) that means for a permanent increase (of one standard deviation) in real output, we expect inflation rate to increase permanently by 0.3 percentage point.

Now to test for long run monetary superneutrality we need to compute the LRD statistic using the long run multipliers that have been estimated. The point estimates of these multipliers can be seen in Table A6.3.39 (c). The long run point estimate of the LRD statistic converges to –0.54 and as shown below (Fig 6.3.32), the 68 per cent confidence

Fig 6.3.32 Computed LRD test statistic
(for superneutrality test)

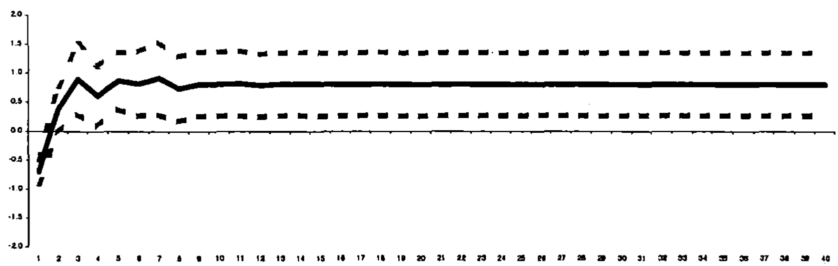


band excludes the zero horizontal axis hence we reject the hypothesis that LRD = 0. Based on this evidence we reject the proposition that real output is not affected by inflation rate (or money growth rate) in the long run, i.e. we reject the long run monetary superneutrality proposition.

The negative bias of output[74] is consistent with the short run analysis finding. This finding provides empirical justification for the reserve bank's commitment to price stability, i.e. high inflation will cause a permanent decline in output hence the need to stabilize prices.

Though not a test of monetary neutrality, the following analysis is important because it tries to answer the question: Suppose real output has changed permanently into a higher level, would inflation rate change also? This is basically a long run view of the aggregate supply equation and will be examined using the LRD framework. The point estimates of the LRD statistics are shown in Table A6.3.39 (d) and are being graphed in Fig 6.3.33 below with the 68 per cent confidence band.

Fig 6.3.33 Computed LRD tests statistic



From Fig 6.3.33 above we clearly see that the zero horizontal axis is not included within the 68 per cent confidence interval so we reject the null hypothesis that LRD = 0. In other words, the inflation rate has significantly changed following a permanent change in real output.

To reiterate some of the important findings of this analysis we see in both the short run and long run analysis that an output shock will cause inflation rate to increase—in line with the aggregate supply equation (or the Phillips curve) formulation. And as to the monetary

[74] This is consistent with Serletis and Koustas (1998) result using Italian data but not with Bullard and Keating (1995) and Rapach (1999)whose results show a positive bias.

supermeutrality proposition, the evidence clearly rejects the hypothesis at the 68 per cent confidence level, i.e. the evidence is more in line with the 'reverse' Mundell-Tobin effect[75].

6.3.8 Robustness test (trivariate VAR)

As explained in the Methodology Chapter estimation of a trivariate VAR is basically to provide a robustness test on the results obtained from the bivariate models.

The three variables for this model are: real output (DGDPR), price level (DCPI), and money aggregate M1 (DM1). Apart from the important economic relationships among these variables, these have been used in the bivariate models of the previous analysis and so it is only logical that they are reestimated in a trivariate format for comparison purposes. In particular it is interesting to see the contemporaneous movements of the three variables given that both price and output have been interchangeably used in the past as the target variables of monetary policy. In fact some countries, including New Zealand, have revised their central bank primary function several times in the past decades, each time with a slightly different emphasis given to output (or employment) and inflation rate[76]. The empirical evidence here should provide useful insight on this issue.

Selecting the order of the VAR

From Table A6.3.40 we see that the AIC, the SBC and the adjusted LR tests all suggest VAR order of 4. However when the VAR model with four lags is estimated there is evidence of both serial correlation and heteroscedasticity. So the number of lags is increased incrementally and at six lags, there seems to be no more evidence of serial correlation but heteroscedasticity still remains—especially in the price equation, so a GST dummy is added. This reduces heteroscedasticity a little but serial correlation starts to appear again. In view of this, the GST dummy is removed and a time trend is included. This provides a slightly better set of diagnostics results though the heteroscedasticity problem still remains.

[75] The reverse Mundell-Tobin effect is that 'a permanent increase in inflation will lower capital stock and real output level'. Inflation erodes real cash balance and consequently reduces the quantity traded in each individual trade. In other words, inflation has a negative 'intensive margin-effect' however inflation has a chance of increasing aggregate output only if it somehow increases the frequency of trades.

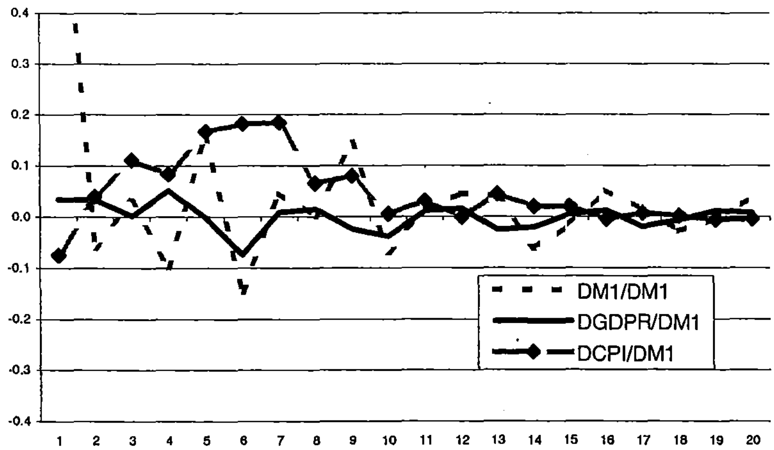
[76] See Dalziel (1993) for a review of this issue.

The cointegration test is carried out with 7 lags[77] and the results are shown in Table A6.3.41. Both the maximum eigenvalue and the trace test fail to reject the null of no cointegration. According to the model selection criteria tests, the SBC test supports the finding of the two Johansen tests whereas the AIC and the HQC choose rank of one. The evidence therefore is more in favour of no cointegration. The final model then is a straightforward VAR in first-difference with six lags, three seasonal dummies, a time trend and a constant.

Impulse and Cumulative Responses

In order to compare the results of this trivariate VAR model with the bivariate models we need to look at the impulse responses and the cumulative responses. Obviously we cannot look at all the responses but we will select the more important responses, such as the responses of output and price to a monetary shock, or the responses of money and price to an output shock.

Fig 6.3.34 Impulse responses of money M1, price and real GDP to money M1 shock



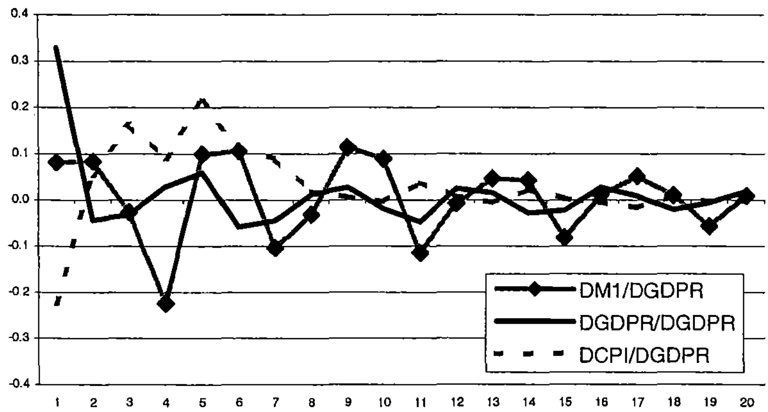
From Fig 6.3.34 above we see that the countercyclical movement of money M1 is still evident, in particular in the 3rd, 4th and 9th quarters. This is also observed in the bivariate models, see for example Fig 6.3.2. Also the magnitudes of both output and money supply are roughly the same. For instance, output maximum response in the bivariate model occurs in the 4th quarter and has a magnitude of $41 million (or 5 per cent)—this is basically the

[77] Because the VAR model in first-difference requires 6 lags, we increase the lags by one when we use level, as when we test for cointegration.

same as observed here in the trivariate model. As to the price response, a very small difference is observed, for example in the bivariate model (see Fig 6.3.17) the response in the 5th quarter is 19 per cent, but here the response is 17 per cent. We do note however slightly stronger responses here than in the bivariate model but generally the response pattern and the magnitudes are roughly the same.

Let us now consider the impact of output shock on the other variables. The responses are shown in Fig 6.3.35 below.

Fig 6.3.35 Impulse responses of money M1, price and real GDP to real GDP shock



Again we see from Fig 6.3.35 that the pattern of movements and the magnitudes of the responses as very similar to the bivariate model responses. For instance, money supply minimum response of just over – 20 per cent in the 4th quarter is also noted in the bivariate model (see Fig 6.3.3). Also the response pattern shown above is more procyclical than countercyclical—just as observed in the bivariate model. With respect to price movements following an output shock, there is no counterpart in the bivariate analysis though the model consisting of inflation and output in the superneutrality test has been estimated. Nevertheless a bivariate model incorporating price and output has been estimated[78] and the responses are very similar to those shown in Fig 6.3.35 above.

[78] The results are not shown in this study because of space constraint.

When we undertook the bivariate analysis of money M1 and real GDP we noted the countercyclical movement of money supply, at least in the first couple of quarters, and we suggested that it could be a response to some inflationary pressure however we could not verify this assertion in a bivariate context. But in a trivariate model, with the price variable included, we can see that indeed there is a significant and sustained increase in price for about two years after money or output shock, i.e. it seems that the countercyclical movement of money is meant to contain the price increase. However this is a fairly complicated process because we note also that money tends to be procycclical when there is output shock so maybe this is one reason why the countercyclical pattern is not so obvious in later periods.

We will look next at the long run responses (Fig 6.3.36) and see whether these are similar to the corresponding responses in the bivariate models.

Fig 6.3.36 Long run responses

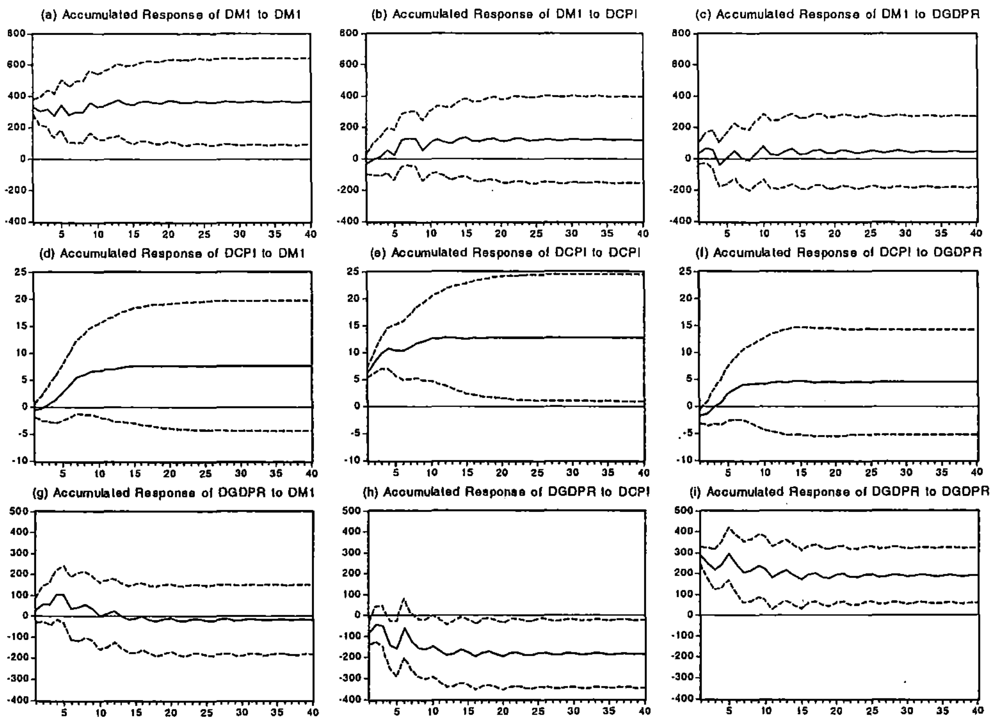
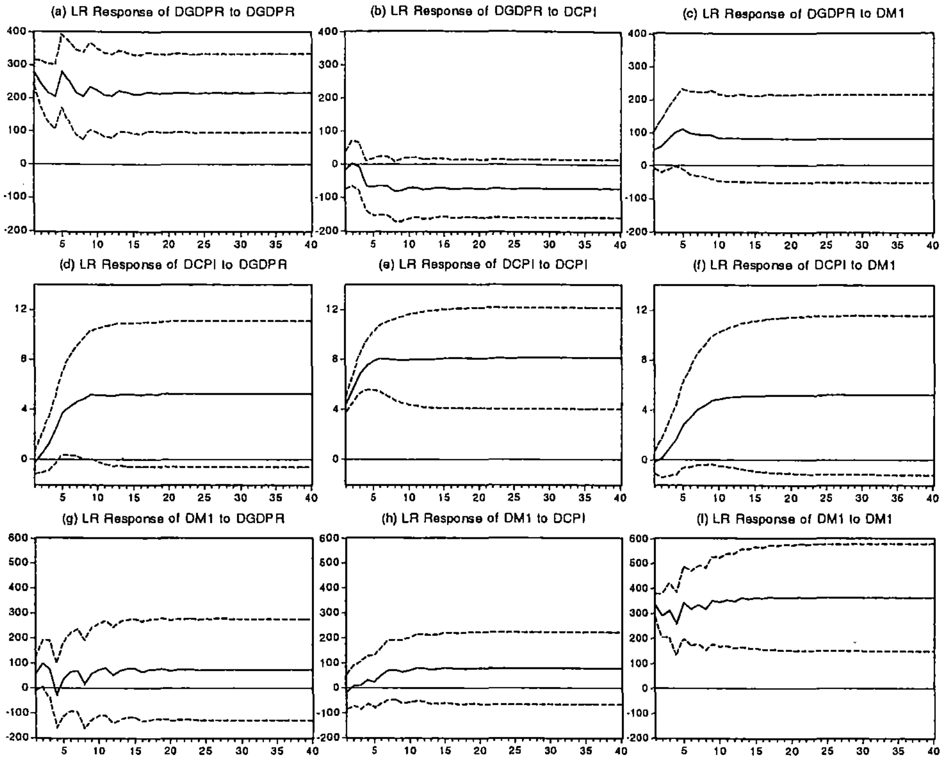


Fig 6.3.37 Long run responses with time variable excluded



The long run responses shown in Fig 6.3.36 and the corresponding responses of the bivariate model (e.g. Fig 6.3.4) are almost the same except for the response of output to monetary shock (part 'g'). In the bivariate model, the point estimate of 15 per cent is positive but is not significantly different from zero at the 95 per cent confidence interval. Here the response is about – 2 per cent, i.e. very close to zero. The difference may lie in the fact that we include the time trend variable here and the model has six lags whereas in the bivariate model there is no time trend and the lag period is only four. To verify this we exclude the time trend and reestimate the model and indeed the response now (Fig 6.3.37) looks very much like the bivariate response. This would mean that the real GDP series has some 'small' deterministic trend that is 'removed' only when the time trend variable is included—thus the zero response noted.

So we see that there are no significant differences in the responses from the bivariate models and the trivariate model[79]. This implies that the concern about the problem of

[79] This is consistent with Bullard (1999) observation that results from larger VAR models generally support results of bivariate VARs.

variable omission in bivariate models is not empirically supported and so one can be confident in interpreting and generalizing the bivariate model results. However it should be cautioned though that the results are very sensitive to the number of lags used and the exogenous or deterministic variables included in the model—so to make meaningful comparisons, one needs to incorporate the same exogenous or deterministic regressors in both models and use the same number of lags.

6.3.9 Summary

The evidence from the bivariate analysis is generally in favour of the neutrality and other classical propositions but the superneutrality hypothesis is decidedly rejected. In addition, the models are generally well specified in terms of the diagnostic test results, except in the case where the price variable is used. The price variable seems to have undergone a major downward shift as from the early 1990s after the introduction of the Reserve Bank Act 1989. Furthermore, the model responses are fairly consistent with macroeconomic theories and standard monetary policy practices. For instance, when inflation or price increases, following a supply side (real output) shock, the short run response of money supply would be a contraction, which is line with the normal 'tightening' practices of central bankers. Also the Monetarist's proposition that inflation is a monetary phenomenon is also supported by the evidence that shows a one-to-one relationship between changes in money supply and changes in price level.

We also see the persistence response of output to monetary shocks that is consistent with empirical findings of other similar studies. And in the case of Fisher's hypothesis, although not very clear-cut, the evidence points more to the confirmation of the hypothesis. The so-called price 'puzzle' is also observed, in particular when the change in price level variable (DCPI) is used. There are two explanations given here—one is to do with the contemporaneous movements of the variables after the initial shock and the other is based on the traditional IS-LM framework.

Finally the trivariate VAR response analysis shows that there is no substantial difference between bivariate model responses and trivariate model responses. In other words, the results and conclusions derived from the bivariate models are robust and can be generalised to larger systems, however caution should be exercised with the specification of the models because the results are quite sensitive to the types of exogenous regressors included in the model and the number of lags used.

Having established some understanding of the numerical values and patterns of the bivariate relationships between real output and nominal variables, such as monetary aggregates, interest rates and inflation, the next part of the study is to look into the monetary transmission mechanisms, i.e. to see how monetary impulses are transmitted to real output in a larger system. This is justified both by the short run dynamics that show distinct responses of output to monetary and inflationary shocks and the long run analysis that clearly rejects the superneutrality proposition. The transmission mechanism, in fact, is becoming a very important topic these days because of the prominent role of monetary policy in day-to-day management of the economy. Unfortunately, complete understanding of the mechanisms is still not yet possible because of the complex issues involved, including the natural differences in the institutions and financial environment of each country. In their preface, Mahadeva and Sinclair (2002) say, *"It is vital that central banks and their observers, worldwide, understand the transmission mechanism so that they know what monetary policy can do and what it should do to stabilize inflation and output"*. The next phase of the study is planned very much in the spirit of this statement—namely the quest for understanding monetary transmission mechanisms in a way that could assist policy makers to quantify the impact of their decisions and to know the time it takes for the effects to be felt.

Chapter 7
EVALUATION OF THE MONETARY TRANSMISSION MECHANISMS

7.1 Introduction

In this chapter the different monetary transmission channels will be estimated, evaluated and compared using the two modes of monetary transmission described in the Methodology Chapter. One is the 'serial' transmission mode and the other is the 'parallel' transmission. To be consistent, the standard VAR will be used for all the transmission models. The impulse responses, the variance decompositions and the Granger-causality test are used as the main tools for the analysis. All the models will be tested for stability, serial correlation and heteroscedasticity using Eviews program. When there is a 'trade-off' question between serial correlation and heteroscedasticity, the former will be considered more important because of the need to have independent or exogenous shocks. Also because the sample size is not very big, a parsimonious model is very much preferred than an over 'parameterised' model—in some cases this may be even at the cost of heteroscedasticity. In consideration of the thesis size regulation, only the test results for the 'parallel' VAR models are reported in Tables A7.2, A7.3 and A7.4 in the appendix, i.e. the bivariate VAR test results are not reported in this thesis but they can be made available if required.

The period of the analysis here is 1984-2002 and in the first two sections the analysis uses New Zealand data. In the third section, starting from sub-Chapter 7.3, the Australian data is used. The comparison between the two countries starts in the same sub-Chapter 7.3.

7.2 Monetary transmission mechanisms in New Zealand

7.2.1 Serial transmission analysis

This is where a series of bivariate VAR models, representing the bivariate relationships within each monetary transmission channel, are estimated and evaluated. The impulse response analysis will be undertaken first then followed by the variance decomposition analysis and lastly the Granger-causality test.

Impulse response analysis

The numerical values of the impulse responses of the five transmission channels are shown in Table 7.2.1. The responses are based on the Cholesky decomposition with the ordering of the variables following the ordering in the theoretical transmission models. For example, in the interest rate channel, the first bivariate model comprising money and interest rate, money leads interest rate, and likewise in the second bivariate model comprising interest rate and fixed investment, the former leads. The shaded responses are the maximum (or peak) responses that will be used in the analysis[1].

The last two columns, DPE/DINT and DCRED/DINT, represent the impulse responses of the equity price and domestic credit to interest rate shock, respectively. These two responses will replace DPE/DM1 and DCRED/DM1 when we consider the impact of interest rate shock rather than money supply shock.

The responses shown in Table 7.2.1 are the responses of the variables following a one standard deviation shock of one of the variables. The actual responses from Eviews program are expressed in the 'original' units of the individual variables but in order to have the same scale and for ease of comparison, the responses have been divided by their respective standard deviation—as is done in the neutrality tests. The unit for the responses therefore is in 'standard deviation units'. A response of 0.15 therefore means 15 per cent of one standard deviation. To give an example, suppose the standard deviation of the interest rate variable is 1.5 percentage point, then a response of 0.2 standard deviation unit (or 20 per cent) equals 0.3 percentage point. In order to be consistent and to avoid confusion the 'per cent' unit will be used throughout the subsequent analysis though the values in the tables and graphs will still be in proportions.

Looking at Table 7.2.1 it is useful to note that the maximum responses seem to be around 20 per cent except for two or three responses. One is the response of domestic credit to the money supply shock in the credit-consumption channel of slightly over 30 per cent that occurs in the 3rd quarter and the other is the response of private consumption to credit shock of over 40 per cent that occurs in the 4th quarter in the same model. Interestingly,

[1] Note also that the 'lag-period' or the 'time-lag' generally refers to the number of quarters up to the first maximum or peak response.

Table 7.2.1: Impulse responses based on the serial transmission mode

Interest rate channel / ***Exchange rate channel***

Lags	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
1	-0.200	0.091	0.212	-0.200	0.138	0.004	0.089
2	0.052	0.080	-0.014	0.052	-0.079	-0.011	0.006
3	0.166	-0.025	0.052	0.166	0.169	-0.087	-0.012
4	0.054	-0.102	-0.043	0.054	0.104	0.064	-0.038
5	0.132	0.018	0.074	0.132	0.055	0.058	0.099
6	0.065	-0.027	-0.036	0.065	0.126	0.008	-0.074
7	0.002	0.010	0.027	0.002	-0.066	-0.199	0.017
8	-0.027	0.014	-0.011	-0.027	-0.051	0.044	0.066
9	-0.009	0.010	0.015	-0.009	-0.053	0.012	0.014
10	-0.001	0.007	-0.004	-0.001	-0.092	0.003	-0.019

Other asset price channel / ***Credit-investment channel***

Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF
1	0.179	0.002	0.097	0.008	0.091	0.212
2	0.014	-0.033	-0.067	0.139	0.043	-0.014
3	-0.170	0.103	0.008	0.309	-0.030	0.052
4	-0.023	0.096	0.021	-0.175	-0.031	-0.043
5	0.188	0.243	-0.025	0.186	0.055	0.074
6	-0.051	-0.051	-0.012	0.013	-0.058	-0.036
7	-0.032	-0.063	0.009	0.123	-0.039	0.027
8	0.030	0.059	-0.004	0.027	0.023	-0.011
9	0.014	-0.060	0.000	0.080	-0.061	0.015
10	-0.008	0.008	-0.009	0.062	0.026	-0.004

Credit-consumption channel

Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE	DPE/DINT	DCRED/DINT
1	0.008	0.210	0.097	-0.044	0.105
2	0.139	0.118	-0.067	-0.155	0.057
3	0.309	0.059	0.008	0.036	0.055
4	-0.175	0.426	0.021	-0.148	0.034
5	0.186	-0.280	-0.025	-0.031	0.114
6	0.013	0.184	-0.012	0.210	0.036
7	0.123	-0.070	0.009	0.000	0.039
8	0.027	0.088	-0.004	0.008	0.017
9	0.080	0.146	0.000	0.039	-0.004
10	0.062	0.105	-0.009	-0.078	0.002

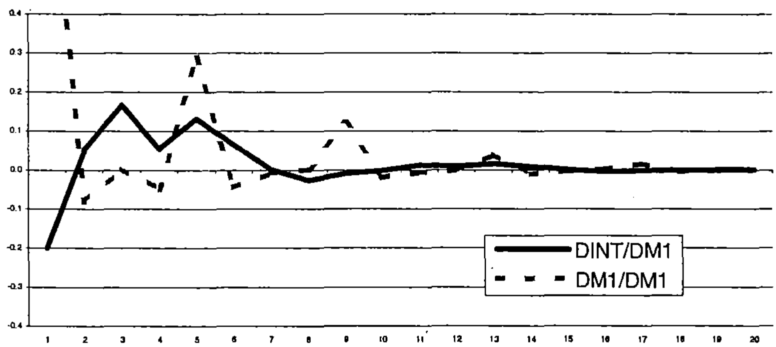
Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1 refers to the response of interest rate to money supply shock and DKF/DINT refers to the response of fixed capital formation to interest rate shock, etc.

when the interest rate shock is used (see the last two columns), the response of domestic credit is relatively small. This would suggest that domestic credit is more sensitive to money supply than to interest rate[2].

[2] In terms of the transmission channels, this evidence would seem to support the bank-lending (narrow credit) channel rather than the 'traditional' money view—contrary to Guender (1998) who finds no evidence for the bank-lending channel in New Zealand.

An interesting pattern can be seen in the response of interest rate to money M1 shock (DINT/DM1). After the money positive shock the interest rate response of 20 per cent in the first quarter is negative—which is what we expect according to the standard supply and demand rule, i.e. when there is excess money supply we expect its price (interest rate) to come down[3]. However in the subsequent six quarters, the interest rate responses are all positive (see Fig 7.2.1 below). This phenomenon is known in the literature as the 'liquidity' puzzle and it would suggest that the central bank, probably in an effort to ward off any inflationary pressure resulting from excess money supply, strongly tightened its monetary policy following monetary positive shock. In other words, it would seem that the interest rate is more exogenous than the money supply in the sense that the interest rate is adjusted

Fig 7.2.1 Impulse responses of interest rate and money M1 to money M1 shock

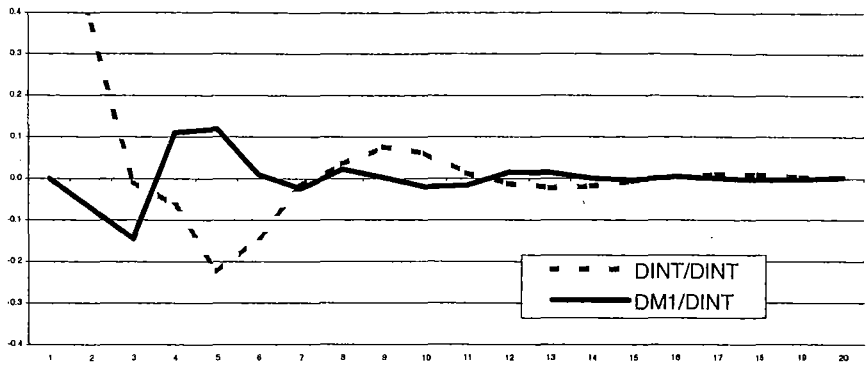


upward by the central bank as to mitigate any inflationary pressure due to the money supply increase. Putting it differently, this implies that money supply is endogenous to interest rates set by policy makers. To verify this we need to examine how money supply and interest rate respond to interest rate movements. This is provided in Fig 7.2.2.

From Fig 7.2.2 we see that after the interest rate shock, the money supply decreases reaching its minimum in the 3rd quarter. After the 3rd quarter it starts to rise again whereas interest rate continues to decline reaching its minimum point of negative 22 per cent in the 5th quarter—the same time as money supply reaches its maximum point (of 10 per cent). In the 7th quarter, both return to their equilibrium values but in the 8th quarter interest rate

[3] Known also as the 'liquidity' effect.

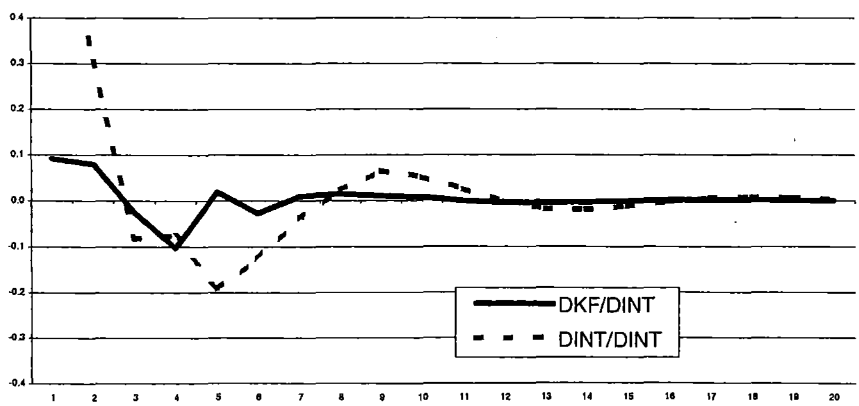
Fig 7.2.2 Impulse responses of money M1 and interest rate to interest rate shock



starts to rise but money supply starts to decrease. This opposite movements of the variables is what theory predicts, i.e. when interest rate increases, we expect money supply to decrease and vice versa[4]. The evidence therefore shows that interest rate leads money, i.e. money supply is endogenous to the movement of interest rate. The implication of this is that the traditional monetary transmission models may be wrong in putting money in front of interest rate, i.e. interest rate should come first followed by money supply—at least according to the New Zealand data.

From Table 7.2.1 we see the relatively low response (only 10 per cent) of fixed investment to interest rate shock. To see how this important relationship evolves over time we plot both fixed investment and interest rate responses in Fig 7.2.3 below.

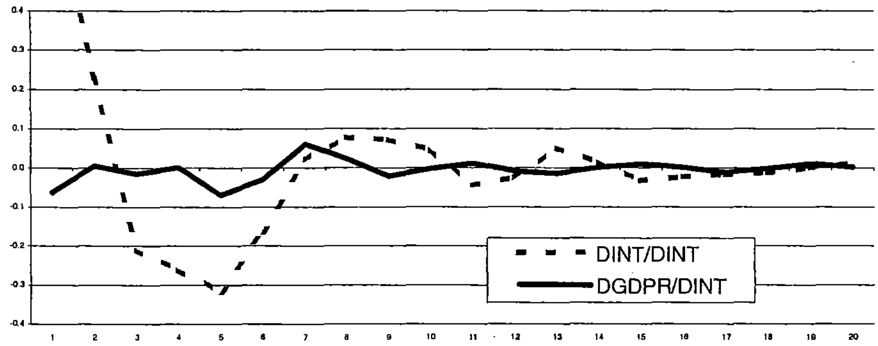
Fig 7.2.3 Impulse responses of fixed investment and interest rate to interest rate shock



[4] This shows that when the source of shock is the interest rate, there is no 'liquidity' puzzle observed.

From Table 7.2.1 and Fig 7.2.3 above, we see that fixed investment starts to respond to interest rate shock from the 3rd quarter but its peak response occurs in the 4th quarter[5]. We also note that the maximum impact of investment shock on output occurs in the 1st quarter therefore we would expect the impact of interest rate shock on output to occur in the 5th quarter (i.e. 1 + 4). In order to verify this we estimate a bivariate model consisting of interest rate and output. The responses are shown in Fig 7.2.4. The peak negative response of output, as predicted, occurs in the 5th quarter[6] and its magnitude of 7 per cent seems plausible given that the maximum impact of interest rate shock on investment is 10 per cent, i.e. we expect output response to interest rate shock to be less than investment

Fig 7.2.4 Impulse responses of output and interest rate to interest rate shock



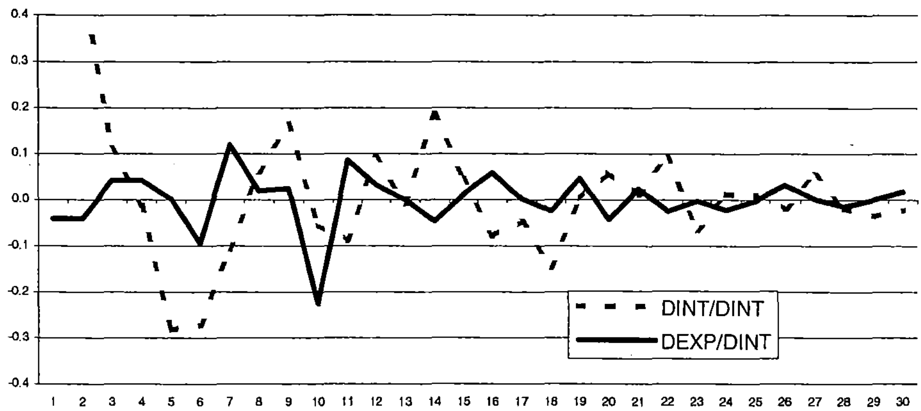
response to the same shock[7]. This is because according to the serial transmission framework, output is 'further' from the source of monetary shock, i.e., investment comes first, then output. In other words, the consistency in the numerical values observed here seems to support the idea of the serial transmission mechanism.

The exchange rate channel shows some delayed responses (see Table 7.2.1). For instance, the peak response of exchange rate following the interest rate shock of 17 per cent occurs in the 3rd quarter[8], but the peak response of exports due to exchange rate shock of 20 per cent

[5] This is within the period of *"six and 24 months"* reported by Bernanke and Gertler (1995).
[6] This would be consistent with Angeloni et al. (2002) finding that *"an unexpected increase in the short-term interest rate temporarily reduces output, with the peak effect occurring after roughly one year"*.
[7] McCarthy and Peach (2002) study finds that following the funds rate increase, residential investment declines by 3 per cent while output declines by 0.3 per cent. So the smaller response of output compared to investment response here seems to be consistent with our result.
[8] This is slightly different to Buckle et al. (2002) result that shows 'the strongest reaction of the exchange rate (after interest rate shock) is after four quarters'.

occurs in the 7th quarter[9]. This would imply therefore that an interest rate shock should have its peak impact on exports ten quarters (or over two years) later—at least according to our serial transmission concept. To confirm this, we estimate a bivariate model consisting of interest rate and export variable. The responses are shown below (Fig 7.2.5), and true enough, the peak negative response of exports following the interest rate shock occurs in the 10^{th} quarter. This provides further evidence of the serial transmission idea. It is also interesting to see a fairly strong response of 22 per cent after such a long time. This would suggest that there could be other factors beside interest rate that drives export.

Fig 7.2.5 Impulse responses of export and interest rate to interest rate shock



In view of the importance of the monetary policy impact on exchange rate, it is useful to trace out the exchange rate response to the interest rate shock. From Table 7.2.1 we see that in the first period after the interest rate shock, the exchange rate appreciates by 14 per cent, then declines in the subsequent period but in the 3^{rd} quarter it peaks at 17 per cent. In the following quarters it starts to decline but still shows positive responses. While there may be other factors influencing exchange rate, as argued by Dalziel (2002), the evidence shown here seems to support the notion that monetary policy via the interest rate has immediate and sustained effect on exchange rate. If we are assume the standard deviation of interest rate is 4 percentage points and the exchange rate standard deviation is 5 cents[10], then a unit

[9] According to the Reserve Bank of New Zealand (2003) forecast, which uses real exchange rate, the peak effect of exchange rate on exports will occur 18 months (less than five quarters) following a 5 percentage points appreciation in the real exchange rate.
[10] In actual fact the TWI is an index number but the 'cents' unit is used here just for illustrative purposes.

percentage increase in interest rate will cause exchange rate to increase by 3.5 per cent (or 0.175 cents) in the first quarter and 4.0 per cent (or 0.2 cents) in the 3rd quarter[11].

Out of the three demand aggregates, viz., fixed investment, private consumption and exports, the fixed investment shock has the largest impact on real output—i.e. output responded by almost 20 per cent in the 1st quarter. Output response to the shocks of the other two aggregates is about 10 per cent—and occurs in the 1st quarter as well. We expect output response to occur instantaneously or at least in the first quarter following the shocks because the three demand aggregates are simply part of output[12] so the evidence here is consistent with our expectation.

Another interesting feature is the relatively higher response of private consumption (DPCE/DCRED) than fixed investment to domestic credit changes (DKF/DCRED). For instance, the peak response of private consumption is 42 per cent and occurs in the 4th quarter while the peak response of fixed investment is only 9 per cent and occurs in the 1st quarter. This would suggest that people borrow more for consumption purposes rather than for fixed investment purposes.

To compare the different transmission models in terms of response magnitude and lag-periods, we need to use the composite or the summary measures discussed in the Methodology Chapter. Table 7.2.2 and Table 7.2.3 contain these summary statistics[13].

Table 7.2.2 follows the 'traditional' ordering of the variables with money leading interest rate, however as noted in the previous analysis, interest rate seems to lead money supply and in view of this, Table 7.2.3 is constructed with the interest rate replacing the money supply. This means that the first column DINT/DM1 in the interest rate and exchange rate channels (see Table 7.2.1) is no longer used while in the other channels money supply is being replaced by interest rate. For instance, DPE/DM1 and DCRED/DM1 are replaced by DPE/DINT and DCREDIT/DINT, respectively.

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[11] According to Dalziel (2002) a 3 percentage point increase in the official cash rate will cause a 6 per cent change in exchange rate.

[12] Because of this direct relationship between output and the three demand aggregates, not many studies have estimated and examined these relationships, i.e. either output is used or one of the demand aggregates.

[13] These summary statistics are obtained by multiplying the peak responses from each bivariate model.

Table 7.2.2: Total lags and summary responses
(traditional channels)

Transmission Channels	*No. of lags*	*Summary Response*
Interest rate channel	6	0.0043 (0.43%)
Exchange rate channel	12	0.0006 (0.06%)
Other asset price channel	7	0.0042 (0.42%)
Credit-investment channel	5	0.0060 (0.60%)
Credit-consumption channel	8	0.0128 (1.28%)

Table 7.2.3: Total lags and summary responses
(modified channels)

Transmission Channels	*No. of lags*	*Summary Response*
Interest rate channel (a)	5	0.0216 (2.16%)
Exchange rate channel (a)	11	0.0030 (0.30%)
Other asset price channel	8	0.0037 (0.37%)
Credit-investment channel	4	0.0011 (0.11%)
Credit-consumption channel	7	0.0024 (0.24%)

Note: (a) The DINT/DM1 responses not included here.

The summary results in the two tables above show that if we think of monetary impulse as moving from variable to variable in a serial fashion, by the time it gets to real output the effect has greatly diminished, i.e. generally less than one per cent. Obviously these summary measures are much less than the direct response of output to a money supply shock (or interest rate shock) of 5-7 per cent noted in the previous neutrality analyses. The discrepancy here highlights the fact that real output is not only affected by a single variable or a single monetary transmission channel, i.e., it is more likely there are several channels operating simultaneously. In fact, what actually goes on between the initial monetary impulse and the final observed effect on output is what most researchers refer to as the 'black box', i.e. up to now nobody actually knows what goes on in the 'interim' though there are several theoretical propositions as to what might have happened. In view of this, the summary measures will be used only to provide numerical values that can be used to compare the different transmission models on a relative basis, i.e. they should not be considered as the estimated response of output for the different transmission models.

From Table 7.2.2 it is obvious that the credit-consumption channel has the largest summary response (1.28 per cent), followed by the credit-investment channel with 0.6 per cent. Next are the interest rate channel and the other asset price effects channel with 0.4 per cent. The last is the exchange rate channel with the summary response of 0.06 per cent. However, when we replace money by interest rate, the credit channels no longer show the largest summary statistics (see Table 7.2.3). Instead, the summary measures of the interest rate and the exchange rate channels seem more significant now. In other words, when money supply is considered as the starting point of the monetary transmission mechanism, the credit channels are significant but when the interest rate is used, the traditional interest rate and the exchange rate channels become more significant. There are two important insights provided by these observations. First, the empirical evidence shows that the credit channel has an important role in monetary transmission channel thus confirming the importance of the financial intermediaries and the banking sector. As argued by Claus and Grimes (2003), *"Financial intermediaries play an important role because they reduce the cost of channelling funds between relatively uninformed depositors to uses that are information-intensive and difficult to evaluate. If banks and other intermediaries provide credit to a large fraction of firms, who otherwise would not be able to borrow, the amount of credit channelled through the banking system can have significant macroeconomic effects, highlighting the importance of public policy in designing policies that ensure the soundness of the banking system*". Empirical studies that have found the importance of the credit channel include that of Bernanke and Blinder (1992), Bernanke and Gertler (1995), Fáckler and Rogers (1993), Holtemoller (2002), Oliner and Rudebusch (1996), among others. The second important insight is that the monetary transmission effectiveness can be affected by the source of monetary shock, i.e. the interest rate shock and the money supply shock have different impact on the transmission process.

In terms of the lag-periods, both the credit channel and the interest rate channel have shorter lags than the exchange rate channel. The exchange rate channel total lag-period of twelve quarters according to Table 7.2.2 and eleven quarters according to Table 7.2.3 implies that it take quite a while before the impact of interest rate via the exchange rate is felt on real output. If we try to trace out where the delay comes from we see from Table 7.2.1 that it comes from the delayed impact of exchange rate on exports (see the DEXP/DEXCH column), i.e. it takes seven quarters (almost two years) before the maximum impact of exchange rate shock is felt on exports. This has important policy implications given that New Zealand depends to a large extent on exports.

Variance decomposition analysis

The following analysis compares the forecast error variance decompositions of the different transmission models. The footnotes to Table 7.2.4 explain how to read the table.

Table 7.2.4: Variance decompositions (%)

A.1. Interest rate channel				*A.2. Exchange rate channel*			
Lags	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
1	4.61	1.76	40.95	4.61	2.84	0.01	10.33
2	4.24	2.71	40.94	4.24	3.69	0.06	9.90
3	6.79	2.61	41.43	6.79	7.12	3.58	10.05
4	7.02	4.29	39.43	7.02	8.21	5.21	11.55
5	8.16	4.28	39.80	8.16	7.86	5.84	19.89
10	8.35	4.45	38.68	8.35	10.92	16.76	26.49
20	8.38	4.45	37.97	8.38	11.12	19.69	30.08
30	8.38	4.45	37.90	8.38	11.13	20.11	30.99
40	8.38	4.45	37.89	8.38	11.13	20.21	31.17

A.3. Other asset price channel				*A.4a. Credit-investment channel*		
Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF
1	3.22	0.00	11.01	0.01	1.60	40.95
2	3.21	0.11	15.25	2.29	1.82	40.94
3	5.86	1.13	15.30	11.45	1.92	41.43
4	5.51	2.00	15.69	13.94	2.07	39.43
5	8.08	7.01	12.60	16.67	2.57	39.80
10	8.27	7.89	12.10	15.61	4.02	38.68
20	8.28	8.26	11.84	15.95	4.69	37.97
30	8.27	8.27	11.79	16.13	4.96	37.90
40	8.27	8.28	11.79	16.20	5.09	37.89

A.4b. Credit-consumption channel					
Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE	DPE/DINT	DCRED/DINT
1	0.01	4.76	11.01	0.20	1.14
2	2.29	6.00	15.25	2.51	1.38
3	11.45	6.32	15.30	2.58	1.45
4	13.94	21.03	15.69	4.27	1.54
5	16.67	25.91	12.60	4.26	2.56
10	15.61	29.55	12.10	8.12	2.77
20	15.95	32.39	11.84	8.24	2.79
30	16.13	33.09	11.79	8.24	2.79
40	16.20	33.55	11.79	8.24	2.79

Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1stands for the proportion of interest rate variance explained by money supply shock, and similarly, DKF/DINT stands for the proportion of fixed capital variance explained by interest rate shock.

From Table 7.2.4 we see that fixed investment innovation explains quite a sizeable amount of output variation—almost 40 per cent. This is followed by exports shock with 31 per cent. Private consumption expenditure shock, on the other hand, explains only 12 per cent of output variation. This would suggest that changes in fixed investment and exports are major factors behind output changes in New Zealand. The significant influence of fixed investment, in particular, is consistent with the findings of the response analysis in which output responds more to investment shock than to any other shock (see Table 7.2.1).

Another significant decomposition reported in Table 7.2.4 is that of domestic credit innovation on private consumption variation—33.6 per cent. This is much larger than the proportion of fixed investment variance (of 5 per cent) explained by the same credit shock. This would suggest that domestic credit in New Zealand is largely used for private consumption purposes rather than for investment purposes. This result is consistent with the finding of the response analysis that shows very little response of fixed investment to domestic credit shock.

Looking at the exchange rate channel in Table 7.2.4 we see that the exchange rate shock explains 20 per cent of exports variance. This is a relatively significant proportion and reflects the important relationship between exports and exchange rate. This significant impact of exchange rate on exports is also observed in the response analysis that shows a 20 per cent response of exports in the 7th quarter. This strong relationship between the two variables may not be too surprising given the 'openness' of the New Zealand economy. As to the relationship between the interest rate and the exchange rate, 11 per cent of the variation in exchange rate is explained by the interest rate shock.

Another interesting observation is the low decomposition of fixed investment variance attributable to interest rate shock, i.e., only 4.5 per cent. This would suggest the conventional money view (or interest rate channel) of monetary transmission is either very weak or not operating. If this is the case, then what does fixed investment respond to? If we look at the credit-investment channel, we also see a very weak impact of domestic credit on fixed investment—just 5 per cent. One possibility is that fixed investment in New Zealand, at least a sizable portion of it, may be funded from foreign sources[14]. There is evidence to confirm this from the work of Enderwick and Akoorie (1994) and Rosenberg (1998). Both noted the apparent increase and significance of foreign investment in New Zealand since 1990. For example, Enderwick and Akoorie (1994) wrote: *First it is apparent that inward investment levels fluctuated over the period, but apparently took a sharp upturn after 1990.* Rosenberg, on the other hand, is more specific on the relationship between foreign investment and fixed investment when she noted, *"A useful indicator as to the importance of foreign investment in relation to New Zealand's total capital requirements is the proportion of foreign investment to Gross Fixed Capital Formation (*fixed investment*). ... Foreign investment averages just under one-quarter (22.6 per cent) of Gross Fixed Capital Formation over the period but varies between 5.6 per cent and 35.6 per cent... For all economies for 1993 it averaged 4.3 per cent, for developed economies 3.5 per cent and for developing economies 7.1 per cent. New Zealand is easily the developed country most dependent on foreign investment by this measure..."*

Now to evaluate and compare the different models, we need an overall statistic that would indicate the effectiveness of each model in explaining the variances of the relevant variables within each model. Again, as in the impulse response analysis, we will multiply the percentages[15] in each model as to get a single measure that we can use for comparison purposes. The results are presented in Table 7.2.5.

Table 7.2.5 Forecast variance summary statistics

Transmission channels	**Period**	**Summary Variance**
A.1 Interest rate channel	40	0.0014 (0.14%)
A.2 Exchange rate channel	40	0.0006 (0.06%)
A.2 Exchange rate channel (a)	40	0.0070 (0.70%)
A.3 Other asset price channel	40	0.0008 (0.08%)
A. 4a Credit-investment channel	40	0.0031 (0.31%)
A.4b Credit-consumption channel	40	0.0064 (0.64%)

(a) In order to have consistent number of decompositions for each model, the 'DINT/DM1' decomposition has been left out in this version of the exchange rate model.

[14] This could be either in the form of overseas borrowing or foreign investment in New Zealand businesses.
[15] Refers to the 40th period decompositions in Table 7.2.4.

Interestingly the 'modified' exchange rate channel has the largest decomposition effect (0.7 per cent) meaning that the shocks in this model explain much of the variations in the variables within the model. This would suggest that this theoretical model is the most consistent with the data[16]. Both the credit channels come second but the credit-consumption channel has much more explanatory power (of 0.6 per cent) compared to the credit-investment channel with 0.3 per cent. The lower explanatory power of the credit-investment channel is due to the very low explanatory power of domestic credit shock on fixed investment variance—as discussed above. Fixed investment shock however explains more of the output variance than private consumption.

The traditional interest rate summary variance figure of 0.14 per cent puts it after the credit channel. This low summary figure would have been higher had fixed investment variance explained well by the interest rate shock, which is expected given standard economic textbook explanation. The fact is, the interest rate shock explains less than 5 per cent of the variation of fixed investment.

The 'other asset price effects' channel is the last in the table implying that the shocks in the model have very little impact on the variations of the variables. In other words, the model does not seem to fit the data well. This result is consistent with Ludvigson et al. (2002) study on US data that *finds little or no sign of a consumption-wealth channel*[17].

Granger-causality analysis

The causality here should be differentiated with the more 'richer philosophical' meaning of causality used in other context. Here the causality is in terms of the extent to which one variable can be explained by the lagged values[18] of the other variables, i.e. more of an inter-temporal statistical relationship than a structural or behavioural relationship. As noted in Enders (1995, p.316) this test is really a 'block causality' test because we are essentially

[16] This seems to confirm Svensson (1998) claim that: *All real-world inflation-targeting economies are quite open economies with free capital mobility, where shocks originating in the rest of the world are important, and where the exchange rate plays a prominent role in the transmission mechanism of monetary policy.*
[17] Consumption-wealth channel is the same as the 'other asset price effects' channel.
[18] This is a 'weaker' concept than 'exogeneity' because the latter includes the contemporaneous values of the explanatory variable as well.

restricting all the lagged values of the relevant explanatory variable to zero. The results are presented in Table 7.2.6 below.

Table 7.2.6: Granger-causality test results (p-values)

Interest rate channel				***Exchange rate channel***			
	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
Normal	0.645	0.426	0.106	0.645	0.455	0.011	0.060
Reverse	0.467	0.035	0.166	0.467	0.877	0.783	0.095
Other asset price channel				***Credit-investment channel***			
	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF	
Normal	0.522	0.242	0.077	0.034	0.920	0.106	
Reverse	0.744	0.061	0.052	0.044	0.084	0.166	
Credit-consumption channel							
	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE				
Normal	0.034	0.159	0.077				
Reverse	0.044	0.719	0.052				

Notes: To read the table, the entries along the row labelled 'normal' refer to the causal orderings as hypothesized in the transmission models. For example, under the 'DINT/DM1' heading, in the 'normal' row, we see a p-value of 0.645. This means that there is no significant Granger-causal effect of money on interest rate, i.e. the dependent variable is the interest rate and the money supply (DM1) is the explanatory variable. The 'reverse' row shows p-values when the causal direction is reversed, for instance, 0.467 under the DINT/DM1 shows the p-value of the Granger-causality effect of the interest rate on the money supply.

From Table 7.2.6 we see mixed results—some results support the 'causal' ordering as stipulated in the transmission models while others do not. For instance, in the interest rate channel, we expect money supply to Granger-cause interest rate yet the p-value (of 0.645) shows the causality effect is insignificant, i.e. past values of money supply cannot explain the contemporaneous changes in interest rate. More interesting though is the insignificant causal-effect of interest rate on fixed investment. In fact, the p-values clearly suggest the opposite, i.e. fixed investment Granger-causes interest rate at the 5 per cent significance level. This phenomenon is often termed 'reverse-causality' and implies that monetary policy makers react to investment movements rather than investment (or investors) reacting to interest rate changes as traditionally conceived. But while this may be inconsistent with the traditional IS-LM model, it is consistent with more recent monetary policy and new-

Keynesian models in which interest rate, in the reaction function, is dependent on output and inflation, i.e. interest rate is endogenous to movements in investment (or output).

The two bivariate relationships that seem to adhere to the theoretical causal ordering are the money-credit (DCRED/DM1) and exchange rate-export (DEXP/DEXCH) relationships. That is, credit movement is dependent on past values of money supply and likewise, export depends on past values of exchange rate movements at the 5 per cent significance level. As to the causal relationships between the demand aggregates (fixed investment, exports and private consumption) and real output, the evidence suggests that the three aggregates Granger-cause output at the 10 per cent significance level. However real output also Granger-causes private consumption at the 5 per cent significance level, and exports at the 10 per cent significance level. This latter phenomenon is known as 'reverse-causality' and sometimes casts doubts on the traditional orderings of the variables or on the exogeneity/endogeneity assumptions of the different macroeconomic schools. For instance, does more investment spending cause increase in output or does the rise in output cause businesses to increase their investment spending? This is important because it may require reformulations of the existing theoretical models.

To compare the different transmission models in terms of the p-values, we need to multiply the p-values in the 'normal' row for each model in Table 7.2.6 to get a single summary p-value—obviously the smaller the summary value the more significant or plausible is the model. These composite p-values are shown in Table 7.2.7.

Table 7.2.7: Granger-causality summary statistics

Transmission channels	**Total p-value**
A.1 Interest rate channel	0.0291
A.2 Exchange rate channel	0.0002
A.2 Exchange rate channel (b)	0.0003
A.3 Other asset price channel	0.0097
A. 4a Credit-investment channel	0.0023
A.4b Credit-consumption channel	0.0004

Note: (b) In order to have consistent number of responses for each model, the 'DINT/DM1' p-value has been left out in this version of the exchange rate model.

From Table 7.2.7 we see that the exchange rate channel yields the smallest 'composite' p-value suggesting that its causal ordering matches well with the data, in particular it is clear that movements in exports is significantly explained by past values of exchange rate and likewise, past values of exports significantly affect output. The exception however is the insignificant causal-effect of interest rate on exchange rate. This would go against the evidence provided in the response and the variance decomposition analysis that shows interest rate shock as having a significant impact on exchange rate. One possible explanation is that the contemporaneous correlation between interest rate and exchange rate is much higher than the correlation between exchange rate and the lagged values of interest rate[19].

As in the previous response and variance decomposition analysis, the credit-consumption channel is quite significant and in fact has almost the same summary value as the exchange rate model. The 'worst' model, in terms of having the least causal effect, is the interest rate channel with a summary p statistic of 0.02. This arises because the money supply does not Granger-cause interest rate, and likewise, interest rate does not Granger-cause fixed investment (see Table 7.2.6). This finding is somewhat consistent with Bernanke and Gertler (1995) who noted the shortcomings of the traditional interest rate channel and consequently looked for other possible transmission channels, in particular the credit channel. The credit-investment and the 'other asset price effects' channels fall in between but the former has more Granger-causal effect than the latter.

Summary

It is useful to recall that even though we talk about five transmission models above, the bivariate relationships involved are actually from individual bivariate models. This is done because in the theoretical models of monetary transmission there is a presumption that monetary impulse flows from one variable to another in a kind of serial fashion. For instance, in the interest rate channel, the monetary impulse is presumed to start from money

[19] Generally the contemporaneous relationship is very important in the impulse response function and forecast error variance decomposition techniques whereas the Granger-causality test depends only on the lagged values of the explanatory variable.

supply, then moves to interest rate, then to fixed investment, and finally to output. Therefore to study this flow, one needs to examine first the responses, decompositions and the Granger-causal effects between money supply and interest rate, then interest rate and investment, and finally investment and output. The use of a bivariate model has also some advantages, such as minimizing the effect of multicollinearity; having more degrees of freedom; and totally 'shutting off' the effect of other variables. One major drawback of this approach is that in real life, there are always more than two variables present and interacting with each other so there is a possibility that the results in this analysis may be bias or incorrect. Nevertheless bivariate relationships, whether they are derived from bivariate VAR models or from larger VARs, are often useful and sometimes quite robust.

Some of the important findings: We note that the maximum impulse responses of the variables to exogenous shocks in the models are generally around 20 per cent—the exceptions are the response of private consumption to credit shock as well as the response of credit to money supply shock. In a way this sets some kind of ceiling or reference point for the responses of the economic variables within a monetary transmission framework. For instance, if we get a response of 50 per cent or over, then we might suspect something is odd or at least it warrants another checking. On the other hand, if we get responses like five per cent, we would not be too alarmed given many responses are actually less than 10 per cent. Whether the 20 per cent response ceiling is restricted only to a VAR approach, or is generally the case in other methods, is not yet known. We also note the summary response statistics are generally less than one per cent. These are much lower than the maximum impulse response (of about 5 per cent) observed when output and monetary aggregate (or interest rate) is estimated directly—as is done in the bivariate neutrality tests. This discrepancy or inconsistency is difficult to explain because the process or the processes involved from the time the monetary impulse starts in the monetary aggregate (or interest rate) to the final policy target (real output or inflation) is still not understood—hence the term 'black box'. In fact, there are several theoretical propositions as to how the transmission might take place, i.e. how the monetary impulse might get transmitted from one variable to another, yet empirical findings sometimes do not support these views. For example, according to the traditional IS-LM framework, investment (and hence output) depends on interest rate yet many empirical studies find weak or no evidence of this[20]. In this study for instance, interest rate does not Granger-cause investment—instead, investment Granger-cause interest rate. Furthermore, the response of investment to interest rate shock is just 10 per cent. To explain this weak or reverse-causality phenomenon, we can think of monetary policy as reacting or responding to investment (or output) movements rather than traditionally viewed. In fact, this observed weakness in the monetary policy tool[21] to influence fixed investment is one reason why other transmission channels, such as the credit and other banking channels, have been proposed. And indeed the importance of the credit channel, in particular the credit-consumption channel, is well supported here.

Despite the extended lag-period, the importance of the exchange rate model is supported by the variance decomposition and the Granger-causality test results. The 'other asset price effects' channel has the weakest effect according to the variance decomposition and the Granger-causality analysis. In terms of the shortest lag-period, the credit-investment and interest rate models come first with the lag-period of about 5 quarters. In other words, the impulse gets transmitted much faster in the interest-credit-investment framework. In spite of some contradictory results observed, such as the weak effect of the interest rate on investment, or the significant delay of the exchange rate effect on exports, most of the empirical results observed here are consistent with the results of other monetary transmission studies.

7.2.2 Parallel transmission analysis

The following analysis will focus on the 'parallel' transmission mode. This is in fact the normal VAR analysis with all the variables in each model included and estimated in 'one go' but the use of the 'parallel' term is to differentiate this transmission mode with the serial mode in which the monetary impulse is assumed to be transmitted along a straight or serial path with no interference from other variables. In other words, in this section real output is assumed to be affected by several factors including the direct impact of the monetary shock itself. The Cholesky decomposition is also used here to identify the

[20] See, for example, Bernanke and Gertler (1995), Mojon et al. (2001), among others.
[21] We are assuming here that interest rate is the monetary policy tool.

structural shocks and the variables are ordered according to the theoretical orderings in the different monetary transmission models. As indicated in the introduction to this chapter, the stability, the serial correlation and the heteroscadasticity test results are shown in Table A7.2 in the Appendix.

The focus in this section is also on the response pattern and magnitude, the lag-periods, the variance decompositions and the Granger-causality test statistics. However in this set-up, it is possible now to examine the direct impact of money supply or interest rate on real output, unlike the serial bivariate approach in the previous analysis where only the second last variable in the transmission model (e.g. investment, exports and private consumption) are allowed to influence output.

Although the VAR models have more variables this time, it is still possible to construct the tables with bivariate relationships embedded in them as in the serial analysis approach. In fact this will be carried out first in order to see whether the bivariate relationships originating from bivariate models are still relevant in the context of larger VARs. After this, we will examine and compare the direct impact of money supply and interest rate shocks on real output in the different transmission models.

Comparison with the serial approach

Table 7.2.8 is the counterpart of Table 7.2.1 in the serial bivariate analysis. Looking at the tables it is quite obvious that the numerical values of the impulse responses and the lag-periods are generally the same. For instance, the maximum impact of the interest rate shock on investment (of 9.7 per cent) occurs in the 4th quarter and in the serial bivariate analysis, the corresponding magnitude is 10 per cent and occurs in the same quarter. Even the extended lag-period (of seven quarters) of the exchange rate impact on export is also noted here. This would suggest that the patterns and characteristics of the bivariate relationships are fairly robust to the size of the VARs. There are however some differences that is worth commenting on given their importance to macroeconomic policies. One is the response of the exchange rate to the interest rate shock. For instance, the peak response here is 28 per cent and occurs in the 4th quarter whereas in the serial bivariate analysis, the peak response is only 17 per cent and occurs in the 3rd quarter. This means that the response in the larger

Table 7.2.8: Impulse responses based on the parallel transmission mode

Interest rate channel				***Exchange rate channel***				
Lags	DINT/DM1	DKF/DINT	DGDPR/DKF	Lags	DINT/DM1	DEXCH/DINT	DEXPT/DEXCH	DGDPR/DEXP
1	-0.261	0.175	0.247	1	-0.096	0.162	-0.059	0.043
2	-0.093	-0.082	-0.042	2	-0.318	0.092	0.001	-0.030
3	0.192	-0.007	0.042	3	0.134	-0.127	-0.172	-0.005
4	0.215	-0.097	-0.007	4	0.189	0.280	0.135	-0.050
5	0.283	-0.042	0.085	5	0.241	0.072	0.037	0.039
6	0.320	-0.003	0.053	6	0.290	0.062	0.008	-0.088
7	0.063	-0.089	-0.018	7	-0.251	-0.163	-0.210	0.014
8	-0.044	0.128	-0.032	8	-0.087	-0.061	0.082	0.048
9	-0.239	0.002	0.011	9	-0.094	0.150	0.041	0.001
10	0.049	0.059	0.026	10	-0.021	-0.238	-0.027	0.003

Other asset price channel				***Credit-investment channel***			
Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	Lags	DCRED/DM1	DKF/DCRED	DGDPR/DKF
1	-0.031	-0.077	0.131	1	-0.025	-0.126	0.230
2	0.009	-0.038	-0.042	2	0.123	-0.044	-0.033
3	-0.099	-0.019	-0.056	3	0.355	-0.021	0.059
4	-0.010	0.021	0.051	4	-0.133	-0.020	-0.034
5	0.129	0.228	-0.040	5	0.148	0.054	0.087
6	-0.297	-0.022	0.012	6	-0.030	-0.100	-0.053
7	0.002	-0.075	0.002	7	0.114	0.083	0.040
8	0.124	0.007	0.008	8	0.003	0.065	0.003
9	0.007	-0.081	0.004	9	0.105	-0.022	0.001
10	0.005	-0.142	-0.033	10	0.040	0.001	0.009

Credit-consumption channel			
Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE
1	0.022	0.069	0.153
2	0.170	0.043	-0.076
3	0.311	0.038	-0.059
4	-0.143	0.233	0.042
5	0.211	-0.312	-0.023
6	-0.096	0.135	-0.013
7	0.170	0.037	0.029
8	0.080	-0.212	0.009
9	0.099	0.303	0.001
10	0.074	-0.015	-0.014

Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1 refers to the response of interest rate to money supply shock, and DKF/DINT refers to the response of fixed capital formation to interest rate shock, etc.

VAR is much higher than in the bivariate setting. One explanation for this is that the bivariate model may have omitted a relevant variable but which is now being included in the larger VAR model. There are several potential candidates but one likely source is the money supply. The reason for choosing this variable is that when we include it in the model, the response of the exchange rate increased quite substantially than before. The other variables have some impact also but generally less than the impact of the money supply. As to the explanation of the increase in response rather than a decrease, this is because of the negative correlation of the money supply and the interest rate and the positive linear relationship between exchange rate and the money supply[22]. That is, in the absence of the money supply, the correlation between the interest rate and the disturbance is negative and so the OLS estimators are likely to underestimate the effect of the interest rate on the exchange rate (see, for instance, Thomas (1993, p. 84, 141)).

Another notable difference is the decline in the peak response of private consumption to credit shock. In the serial bivariate analysis the response is 43 per cent in the 4^{th} quarter but here it is only 30 per cent and occurs in the 9^{th} quarter, i.e. the relationship seems to be stronger in the serial case than in the larger VAR context. This can be explained on the basis of the contemporaneous positive correlation between the domestic credit and the money supply (see Table A6.1) and on the positive coefficient of the credit variable in the private consumption (DPCE) equation. Because both of these are positive we expect the marginal impact of credit on private consumption in the bivariate model to be overstated. Again this is a symptom of an omitted variable which in this case is money supply. It is useful to note though the difference in the bias here and the bias noted in the case of the exchange rate and the interest rate above. This difference is basically due to the different signs of the correlations, for example here the correlation between the money supply and the domestic variable is positive while the correlation between the interest rate and the money supply is negative.

Also looking at the response of the equity price to money supply shock there is a substantial difference in the bivariate model figure and the parallel VAR figure. What this means is that the relationship is not very robust to the size of the VAR model. Interestingly, when the interest rate is used, the relationship is fairly robust[23]. This would suggest that the effect of the interest rate on the equity price is more permanent or invariant.

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[22] The correlation coefficients are reported in Table A6.1 in the Appendix. For the regression equation of the exchange rate see Table A7.3.4.

[23] Unfortunately because of space constraint, the responses of the model with the interest rate is not reported here. Another reason is that the intention in this study is to use the standard monetary transmission theories which happen to start off with the money supply (see Mishkin, 1995).

Below is the summary tables based on Table 7.2.8 and is similar to Table 7.2.2 and Table 7.2.3, i.e. the summary responses are the products of the peak responses from the bivariate relationships within each transmission model and the total lags are the sums of the lag-periods from the same bivariate relationships.

Table 7.2.9 Total lags and summary responses
(traditional channels)

Transmission channels	*No. of lags*	*Summary response*
Interest rate channel	6	0.0063 (0.63%)
Exchange rate channel	14	0.0008 (0.08%)
Other asset price channel	11	0.0039 (0.39%)
Credit-investment channel	11	0.0068 (0.68%)
Credit-consumption channel	13	0.0144 (1.44%)

Table 7.2.10 Total lags and summary responses
(modified channels)

Transmission channels	*No. of lags*	*Summary response*
Interest rate channel (a)	5	0.0239 (2.39%)
Exchange rate channel (a)	12	0.0025 (0.25%)
Other asset price channel	8	0.0037 (0.37%)
Credit-investment channel	6	0.0008 (0.08%)
Credit-consumption channel	8	0.0054 (0.54%)

(a) The DINT/DM1 response is excluded

Looking at the tables above, the two credit channels summary responses are very much reduced when the monetary source of shock is interest rate. This is noted also in the serial bivariate analysis and is an important feature of the New Zealand economy because it shows that domestic credit is not very responsive to interest rate. In contrast, both the interest rate and the exchange rate channels show more prominence when the source of shock is interest rate.

In view of the similarities in the impulse and summary responses noted here and in the serial analysis the comments already made in the previous serial analysis is applicable here too.

We will examine next the variance decompositions of the different transmission models. The decompositions are reported in Table 7.2.11 below. The instruction to read the table is provided in the footnote.

Table 7.2.11: Variance decompositions (%)

Interest rate channel				***Exchange rate channel***			
Lags	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
1	10.16	5.24	51.75	1.43	2.81	1.84	2.32
2	10.05	5.49	50.28	12.91	3.48	1.59	3.21
3	13.78	4.75	50.39	13.09	4.56	12.76	2.81
4	15.01	5.84	48.72	14.30	10.52	15.74	4.70
5	17.63	5.88	47.05	14.71	9.58	14.67	5.46
10	21.27	7.96	46.25	17.71	13.05	18.83	9.22
20	22.54	8.11	42.46	16.89	12.66	20.77	12.88
30	22.68	8.32	42.02	17.13	13.72	19.94	13.28
40	22.68	8.35	41.67	17.10	14.07	20.41	13.07
Other asset price channel				***Credit-investment channel***			
Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF	
1	0.14	0.78	19.24	0.10	3.25	42.69	
2	0.13	0.91	20.37	2.05	2.98	42.52	
3	1.14	0.81	21.47	14.65	2.70	41.25	
4	1.10	0.82	22.92	14.54	2.70	39.31	
5	2.48	5.13	18.19	15.27	3.05	40.22	
10	9.37	7.32	15.91	13.10	5.67	38.23	
20	9.83	8.32	15.59	12.37	6.32	37.71	
30	9.88	8.49	15.42	12.24	6.38	37.39	
40	9.91	8.55	15.38	12.19	6.40	37.27	
Credit-consumption channel							
Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE				
1	0.07	0.70	22.41				
2	3.26	0.91	26.28				
3	11.37	0.91	27.28				
4	12.23	6.49	27.93				
5	15.21	13.37	21.79				
10	16.17	21.72	20.30				
20	16.54	21.78	19.42				
30	16.89	21.76	19.21				
40	17.09	21.74	19.10				

Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1 stands for the proportion of interest rate variance explained by money supply shock, and similarly, DKF/DINT stands for the proportion of fixed capital variance explained by interest rate shock.

From Table 7.2.11 we see that the proportions (or percentages) are roughly the same as those in Table 7.2.6 except for one or two decompositions—in fact, these differences come from the same exchange rate model. One is the decomposition of output variance with respect to export shock (DGDPR/DEXP) and the other is interest rate variance with respect to the money supply shock (DINT/DM1). In the serial model analysis, the output variance explained by the export shock is about 30 per cent but here it is only 13 per cent, i.e. it seems the explanatory power of export shock decreases when more variables are present. This would suggest that there may be an omitted variable bias in the bivariate model and whose effect has been 'corrected' by the inclusion of more variables this time. In particular, the addition of the exchange rate variable seems to have affected the explanatory power of the export shock on output substantially. In the case of DINT/DM1, the situation is reversed, i.e. the explanatory power of the money supply shock seems to be enhanced going from 8 per cent in the bivariate model to 17 per cent in the larger VAR here. However this occurs because the number of lags used in the bivariate model is only four whereas in the larger VAR we use seven lags[24]. If the number of lags in both models is the same, the decompositions are found to be roughly the same, i.e. about 20 per cent. These two cases demonstrate well the potential problem with a VAR approach—that of omitting a relevant variable or using a different number of lags. In each case we might get totally different responses or variance decompositions. In other words, one should be very careful in comparing impulse responses and variance decompositions between VAR models that have different specifications.

As with the analysis of the impulse responses, the similarity of the decompositions observed here with the previous serial bivariate analysis means that the comments made earlier are applicable to the decompositions reported here too. Because of this similarity and the fact that the variance decomposition uses the same structural shocks as the impulse response tool, the summary statistics for the variance decompositions are not estimated here.

The Granger-causality test results are reported in Table 7.2.12. This is the counterpart of Table 7.2.6, and as with the responses and the variance decompositions we see here again strong similarities in the results. The few differences noted will be discussed below.

[24] The longer lag used is necessary in order to remove serious serial correlation in the model.

Table 7.2.12: Granger-causality test results (p-values)

Interest rate channel				***Exchange rate channel***			
	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
Normal	0.616	0.960	0.729	0.324	0.595	0.070	0.026
Reverse	0.639	0.737	0.947	0.438	0.734	0.586	0.402
Other asset price channel				***Credit-investment channel***			
	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF	
Normal	0.637	0.634	0.002	0.015	0.906	0.211	
Reverse	0.869	0.362	0.071	0.103	0.072	0.389	
Credit-consumption channel							
	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE				
Normal	0.009	0.161	0.007				
Reverse	0.015	0.126	0.082				

Notes: To read the table, the entries along the row labelled 'normal' refer to the causal orderings as hypothesized in the transmission models. For example, under the 'DINT/DM1' heading, in the 'normal' row, we see a p-value of 0.616. This means that there is no significant Granger-causal effect of money on interest rate, i.e. the dependent variable is interest rate and the money supply (DM1) is the explanatory variable. The 'reverse' row shows p-values when the causal direction is reversed, for instance, 0.639 under the DINT/DM1 shows the p-value of the Granger-causality effect of the interest rate on the money supply.

The p-value of the reverse-causality of investment on interest rate in the serial bivariate model is 0.035 (see Table 7.2.6), i.e., significant at the 5 per cent level, yet we see here (Table 7.2.12) above that the p-value (of 0.737) is not significant. What happens here is that fixed investment and output are highly correlated[25] so in the absence of output, investment tends to show strong Granger-causal effect on interest rate, i.e. acts a proxy for output. When the output variable is present, the Granger-causal effect of investment is greatly reduced.

Another significant difference in the p-values is that of the reverse-causality of output on exports. In the serial bivariate model the p-value is 0.095 (i.e. significant at the 10 per cent level) but here it is 0.402, i.e. not significant. This occurs because the exchange rate has a strong Granger-causal effect on exports so output Granger-causal effect is greatly reduced

[25] In level the correlation coefficient is 92% and in first-difference it is 41% (see Table A6.1 in the Appendix).

when the exchange rate is included. The large p-values of the causal (and reverse-causal) effect of price of equity on private consumption here relative to their counterparts in the serial analysis is also due to the strong Granger-causal effect of output on price of equity, i.e. the Granger-causal effect of private consumption is greatly reduced by the presence of output variable. Other than these, the Granger-causal test results of the serial and the parallel approaches are basically the same.

In terms of the summary statistics, the table below is the counterpart of Table 7.2.7. Note that even though the statistics used for this table come from the parallel approach, the individual p-values used (see Table 7.2.12) still represent bivariate relationship, i.e. not multivariate relationships.

Table 7.2.13: Granger-causality summary statistics

Transmission channels	**Total p-value**
A.1 Interest rate channel	0.4311
A.2 Exchange rate channel	0.0004
A.2 Exchange rate channel (b)	0.0011
A.3 Other asset price channel	0.0008
A. 4a Credit-investment channel	0.0029
A.4b Credit-consumption channel	0.00001

Note: (b) In order to have consistent number of responses for each model, the 'DINT/DM1' p-value has been left out in this version of the exchange rate model.

From Table 7.2.13, it is clear that the credit consumption channel is the most significant channel followed by the exchange rate channel and the 'other asset price channels. The interest rate channel is not significant. These results are fairly consistent with the results presented for the serial analysis in Table 7.2.7. What these results suggest then is that despite the size of the VAR used, it is the bivariate relationship among the variables present that is quite important.

Our next analysis will concentrate on the more direct relationship between the monetary shock (i.e. the money supply or the interest rate shock) and real output in the different transmission models. As explained in the methodology chapter, this is not possible to do in the serial transmission framework because the money or interest rate variable are at the 'front' of the transmission channel whereas output is at the 'end', i.e. it is the last variable in the channel. However in the parallel transmission mode this is possible because all the variables are able to affect each other therefore the following 'direct' analysis is actually part of the 'parallel' transmission analysis. This approach is in fact the approach adopted by most empirical VAR studies on the monetary transmission process.

7.2.3 Direct transmission analysis

It is important to stress here that even though we are talking about a single source of monetary shock (e.g. money supply or interest rate), the impact or effects observed at some later stage, on real output, or any variable for that matter, is in fact the resultant of interactions and feedbacks from all the variables within each model[26]. This is one of the weaknesses of the VAR framework and this is one main reason why the serial and parallel transmission ideas are introduced in this study.

The output responses are shown in Fig 7.2.6 and Fig 7.2.7 and in order not to clatter the graph we will have no other responses shown and no confidence band drawn[27]. Not showing the confidence band is justified because the confidence bands around the responses of detrended or stationary variables generally embrace the horizontal axis (see, for example, Fig 6.3.1, Fig 6.3.11, etc.) hence it will be of little use to have these drawn. In any case, what we are more interested in is the magnitude of the output response and the lag-period for each transmission channel so that we can evaluate and compare each other.

Because of the unresolved issue of whether money aggregate or interest rate is an important monetary policy tool or intermediate policy target we will look at both[28]. Fig 7.2.6 shows

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[26] As pointed out by Christiano et al. (1998), *"A given policy action and the economic events that follow it reflect the effects of all the shocks to the economy"*.

[27] Other previous studies that do not show the confidence band around impulse responses include that of Angeloni et al. (2002); Bernanke and Gertler (1995); McCarthy and Peach (2002); Morsink and Bayoumi (2001), among others. Mojon and Peersman (2001) also noted the *large confidence bands around the responses in a VAR model making it difficult for meaningful conclusions to be made*. And Hayo (1999) argued that *'statistical significance does not say a lot about economic significance'*.

[28] As noted by Brunner and Meltzer (1990), *"An often contentious issue about monetary control concerns the central's bank use of an interest rate or a monetary aggregate as a target or control variable"*. And according to Leeper et al. (1996), *"There is a long tradition in monetary economics of searching for a single policy variable—perhaps a monetary aggregate, perhaps an interest rate—that is more or less controlled by policy and stably related to economic activity"*.

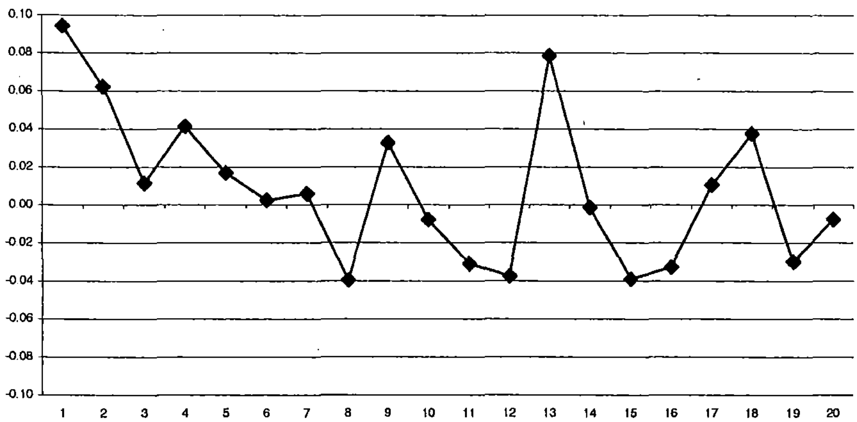
output response to monetary aggregate shock for the five transmission channels while Fig 7.2.7 shows output response to interest rate shock.

From Fig 7.2.6 we see that generally the responses of output to money supply shock in all the five transmission models are less than 10 per cent—the average would be around 5 per cent. This magnitude is also observed in the bivariate models. Another interesting feature is the different patterns of the responses across the models, both in terms of the peaking periods and magnitudes. This would suggest that in the real economy, with so many variables and transmission channels present, the response of output would be extremely difficult to predict.

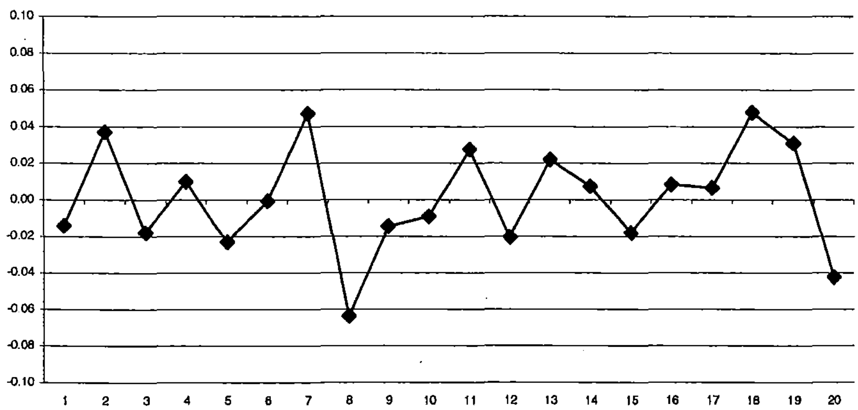
Comparing the magnitudes of the responses, the largest response seems to come from the traditional interest rate channel. We see, for instance, that the first large response of 9.4 per cent occurs in the first quarter after the money supply shock while the second one (of 7.8 per cent) occurs in the 13th quarter (about three years later). This is quite an interesting observation but it is consistent with the notion that investment spending can affect the economy instantly (in the 1st quarter) and also at some later time when the investment projects start to generate income or value added. Another interesting observation is that of output response in the exchange rate channel. It shows several siginificant responses: one in the 2nd quarter of 3.7 per cent; another in the 7th quarter of 4.7 per cent; and one in the 18th quarter (over four years later) of 4.7 per cent. This delayed but sustained response of output to money supply shock is also noted in the serial analysis. One possible reason for this multiple and extended set of significant responses is the fact that the exchange rate model contains variables that are bound to be affected by overseas influences as well (see, for example, Buckle et al., 2002). As to the 'other asset price effects' channel, the maximum response of output of 6.5 per cent occurs in the 3rd quarter. Another significant peak (of 5 per cent) occurs in the 11th quarter, i.e. about two years later. Out of the two credit channels, the credit-consumption channel seems to show more significant response (of 4.6 per cent)—this result is consistent with the serial approach findings.

Fig 7.2.6 Output response to money supply shock

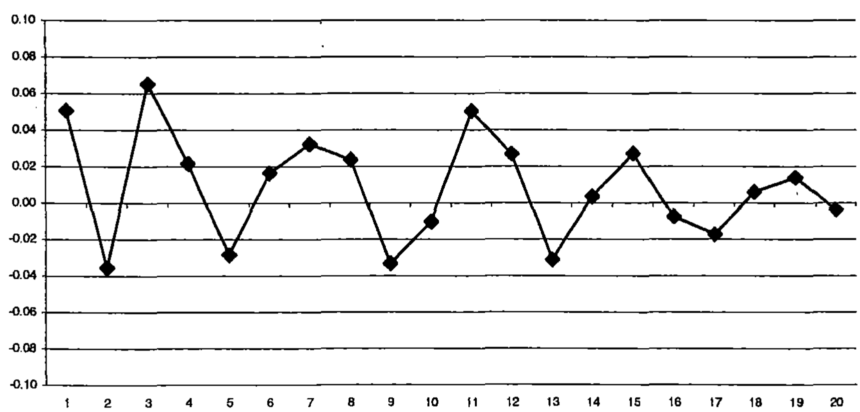
(a) Interest rate channel



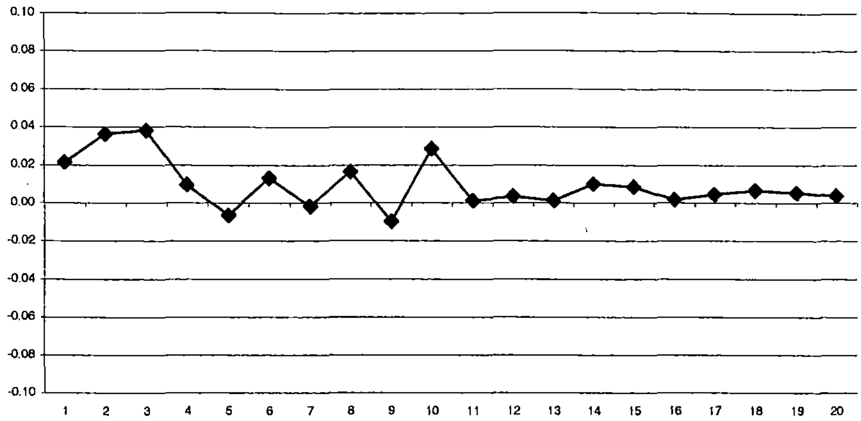
(b) Exchange rate channel



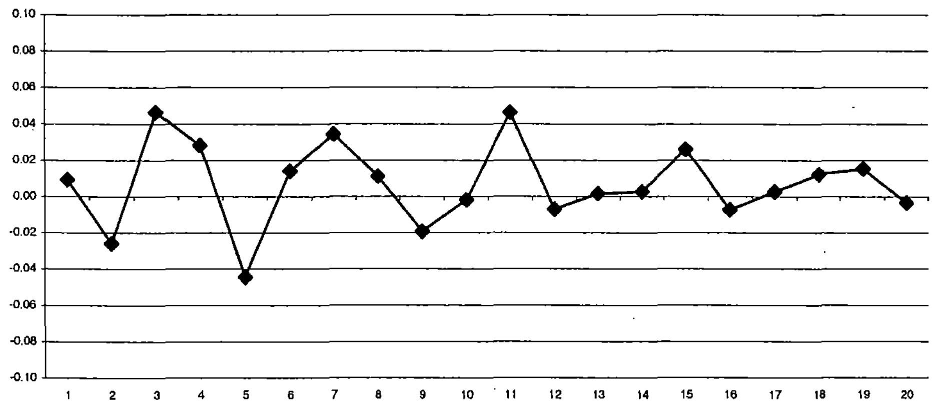
(c) Other asset price (consumption wealth) channel



(d) Credit-investment channel



(e) Credit-consumption channel



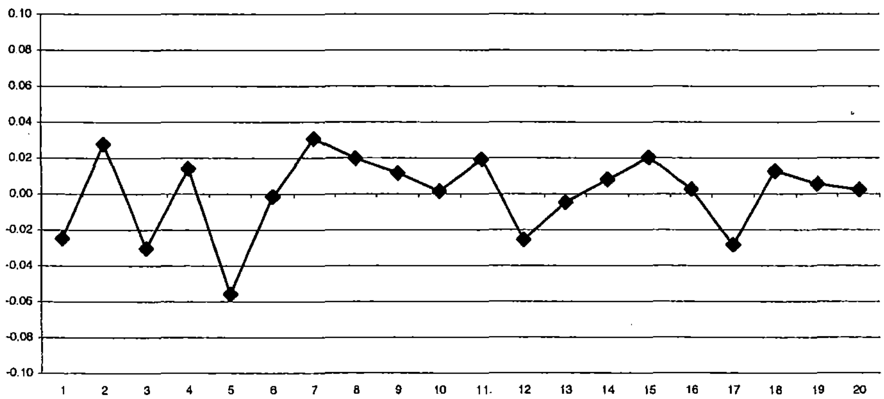
To reiterate the main results observed, the maximum response of output comes from the interest rate channel—one in the 1st quarter and the second in the 13th quarter (about three years later). Following the interest rate channel is the 'other asset price effects' channel with a maximum response occurring in the 3rd quarter. The exchange rate channel exhibits several peak responses but the more significant responses occur much later in the 7th and 18th quarters. The smallest output responses are observed from the two credit channels. Clearly the results obtained here are different to the predictions of the serial and parallel transmission approaches summarised in Table 7.2.2, 7.2.3, 7.2.9 and 7.2.10. This provides the evidence that output response to a monetary policy shock is extremely difficult to predict or discern from any particular monetary transmission model.

We will now examine output response following interest rate shock for the different transmission channels. These are shown in Fig 7.2.7 below. Note however that the maximum responses of output refer to the negative peak values because of the negative correlation between interest rate and output.

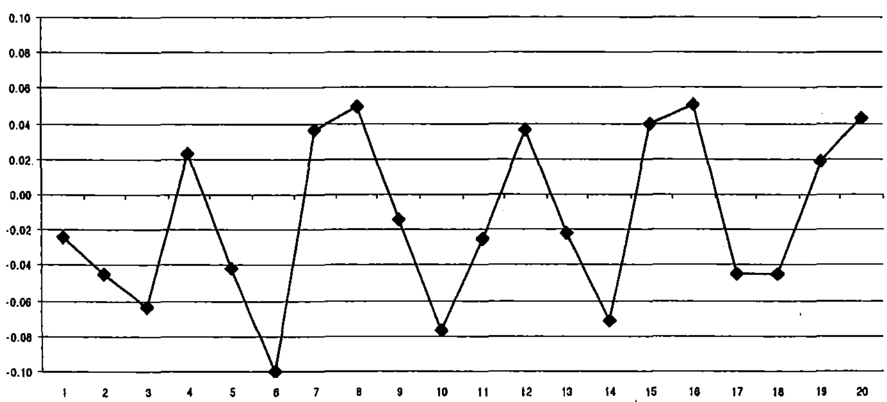
Looking at the interest rate channel in Fig 7.2.7 we see the peak response of output of 6 per cent occurs in the 5th quarter[29] while in the exchange rate channel the peak response of 10 per cent occurs in the 6th quarter—this seems to be the opposite of what happens when

Fig 7.2.7 Output response to interest rate shock

(a) Interest rate channel

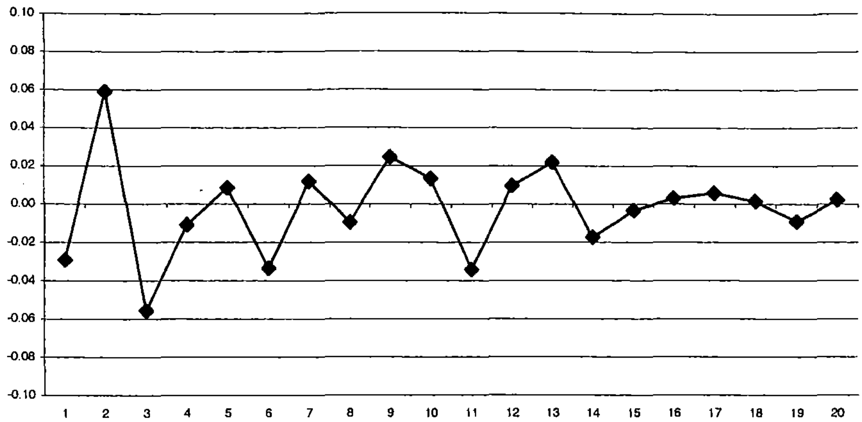


(b) Exchange rate channel

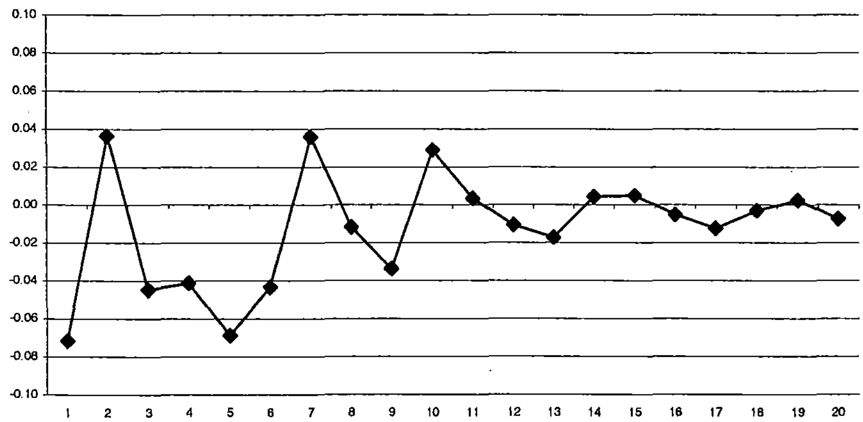


[29] This is broadly consistent with Bernanke et al. (1997) finding that indicates *"eighteen to twenty-four months* (or 4.5 to 6 quarters) *for output to reach its trough after the interest rate shock"*. Also it is consistent with Angeloni et al. (2002) who reported: *In the VARs, an unexpected increase in the short-term interest rate temporarily reduces output, with the peak effects occurring after roughly one year.* Mojon and Peersman (2001) also reported four quarters for the GDP peak response to a contractionary monetary policy.

(c) Other asset price (consumption wealth) channel



(d) Credit-investment channel

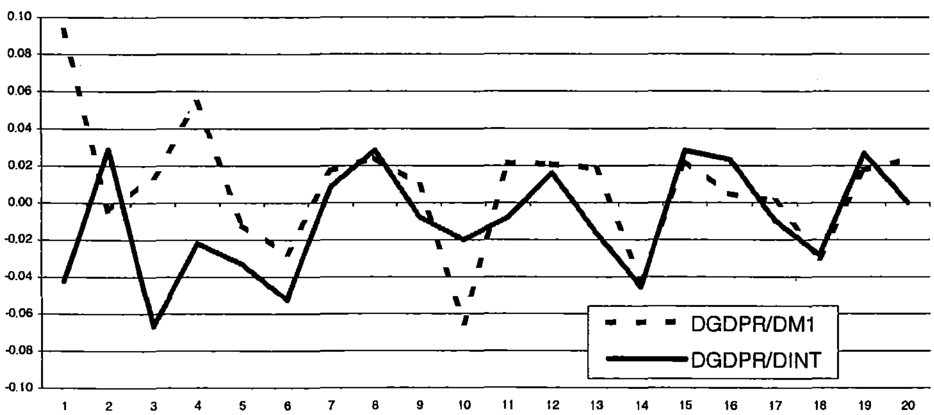


(e) Credit-consumption channel

money supply shock is used. This would suggest that in New Zealand the exchange rate model seems to propagate monetary impulse more effectively if the source of shock is interest rate, however if the source of monetary shock is money supply, then the traditional interest rate channel would be a more efficient 'mechanism' in the sense that higher output response would result. The 'other asset price effects' channel shows a fairly distinct peak response (of 5.6 per cent) in the 3rd quarter after which it seems to level off. As to the other two credit channels they both seem to show significant and sustained responses in the first couple of quarters but after six quarters or so they levelled off. These responses are also slightly higher than the responses following the money supply shock.

In summary we see that all the transmission channels seem to depict significant responses in the first few quarters (at least up to the 6^{th} quarter) before they die out. In the previous analysis, when the money supply shock is used, some significant responses occur in the 8^{th} and 13^{th} quarters. It is also noted that the absolute values of the responses are slightly higher here compared to the responses when the money supply shock is used so an interesting question now is: Does the evidence suggest that interest rate shock has more impact on real output than money supply shock? In order to address this question it may be useful to look at an encompassing model[30] that incorporates all the variables used so far and see how output responds to both the interest rate shock and the money supply shock. These responses are shown in Fig 7.2.8 below.

Fig 7.2.8 Output response to money supply and interest rate shocks
The encompassing model



[30] Morsink and Bayoumi (2001) also set up and estimated a 'summary' model after estimating and evaluating smaller and more specific models.

Looking at the encompassing model the response of output to the money supply shock in the first quarter is almost 10 per cent while the corresponding response following the interest rate shock is 4 per cent. The next output peak response following the money supply shock is in the 4th quarter whereas the peak response following the interest rate shock occurs in the 3rd quarter. These two peaks have roughly the same magnitude of about 6 per cent but the response due to interest rate shock is more sustained—at least up to the 6th quarter. Also from the 5th quarter onwards, both responses seem to follow the same trend—which is that of output response due to interest rate shock, i.e. interest rate effect seems to be dominating the money supply effect—as reflected in the predominantly negative responses. So the evidence provided by this encompassing model would suggest that while output responds immediately and significantly to money supply increase, the effect seems to die out quickly. In contrast the effect of the interest rate shock comes later in the 3rd quarter but remains significant for the next couple of quarters, i.e. more sustained.

Now as to which of the monetary transmission models closely resembles the encompassing model's response this is difficult to say by looking at the responses in Fig 7.2.6 and Fig 7.2.7. That is, it seems the response patterns observed from the transmission models are all different. This provides further evidence of the difficulty in identifying exactly how the monetary impulse gets transmitted to real output.

Variance decomposition analysis of output

Here we will look at how much of the variation in output is being explained by the different shocks within each model. The larger the proportion that is explained by the shocks other than output shock itself, the more plausible is the model. The decompositions are shown in Table 7.2.14.

Out of the transmission channels in Table 7.2.14, the traditional interest rate channel and the exchange rate channel explain more than 60 per cent of output variation—in contrast, the 'other asset price effects' and the credit-consumption channels can only explain less than 40 per cent.

In the case of the interest rate channel it is the significant explanatory power of fixed investment shock on output variance (42 per cent) that gives the whole channel its

Table 7.2.14: Output (DGDPR) variance decomposition (%)

	Interest rate channel				*Exchange rate channel*				
	DM1	DINT	DKF	DGDPR	DM1	DINT	DEXCH	DEXP	DGDPR
1	7.56	0.52	51.75	40.17	0.25	0.76	6.35	2.32	90.32
2	10.25	1.10	50.28	38.36	1.85	3.04	6.04	3.21	85.86
3	10.10	1.79	50.39	37.72	1.93	6.73	9.12	2.81	79.41
4	11.05	1.89	48.72	38.34	1.80	6.44	13.19	4.70	73.86
5	9.78	3.68	47.05	39.49	2.06	7.22	12.93	5.46	72.32
10	10.63	4.27	46.25	38.84	4.95	15.69	15.11	9.22	55.02
20	15.18	4.68	42.46	37.69	6.50	18.65	17.50	12.88	44.48
30	15.55	4.69	42.02	37.74	7.19	21.52	17.55	13.28	40.46
40	15.79	4.74	41.67	37.80	7.59	23.05	18.19	13.07	38.10

	Other asset price channel				*Credit-investment channel*			
	DM1	DPE	DPCE	DGDPR	DM1	DCRED	DKF	DGDPR
1	2.87	0.26	19.24	77.62	0.37	0.00	42.69	56.94
2	4.12	0.55	20.37	74.97	1.40	0.25	42.52	55.82
3	7.85	0.50	21.47	70.18	2.32	3.66	41.25	52.77
4	7.93	1.64	22.92	67.51	2.23	3.88	39.31	54.58
5	6.48	2.82	18.19	72.51	2.04	3.85	40.22	53.89
10	7.17	11.28	15.91	65.64	2.55	5.15	38.23	54.07
20	9.22	12.05	15.59	63.15	2.58	5.52	37.71	54.19
30	9.55	12.14	15.42	62.89	2.63	5.68	37.39	54.30
40	9.62	12.26	15.38	62.74	2.65	5.73	37.27	54.35

	Credit-consumption channel			
	DM1	DCRED	DPCE	DGDPR
1	0.08	0.13	22.41	77.37
2	0.68	0.14	26.28	72.90
3	2.43	1.86	27.28	68.43
4	3.00	2.21	27.93	66.86
5	3.54	1.75	21.79	72.92
10	4.23	5.38	20.30	70.09
20	5.69	5.63	19.42	69.26
30	5.88	5.76	19.21	69.15
40	5.95	5.85	19.10	69.10

importance. And as to the exchange rate channel, it is the combination of exchange rate and exports explanatory power that raises the explanatory power of the channel. This provides evidence that the variables, i.e., fixed investment, exchange rate, and exports, have significant influence on real output changes. This seems plausible given the classical role of fixed investment in promoting economic growth. And in the case of the exchange rate and the export variables, these are very important variables for small open economies like New Zealand which rely heavily on external trade.

Focusing on the individual variables we see that the single most influential variable is fixed investment (DKF) with explanatory power of about 40 per cent. The other two demand aggregates, viz., private consumption (DPCE) and exports (DEXP) can only explain less than 20 per cent. In terms of the money supply shock, it is from the interest rate channel that we see its largest explanatory power of 16 per cent—interest rate shock, on the other, explains less than five per cent. And the weakest money supply shock comes from the credit-investment channel with less than 3 per cent explanatory power[31]. When we look at exchange rate channel we see that the explanatory power of money supply and interest rate shocks seem to be reversed (compared to the interest rate channel) with the latter showing more influence this time, i.e. 23 per cent against 7 per cent for money supply shock[32]. This highlights the sensitivity of the VAR results to the specification of the model and the number of lags used.

Granger-causality test for output

The results of the Granger-causality test are presented in Table 7.2.15. What the test does is to exclude the entire lags of a particular variable, say money supply, or whatever the variable in question, and then test whether the exclusion of these lags makes any significant impact on the model—if not, then the variable whose lags have been excluded is considered as not having any Granger-causal effect, otherwise it is significant. The significance or otherwise of the variable is indicated by the 'Prob' or p-value shown on the right-hand side of the table. The 'All' p-value in the last row of each model stands for the model as a whole.

From the table we see that the 'other asset price effects' channel has the minimum overall p-value (of 0.006) followed by the exchange rate channel (with 0.102) and the credit-consumption channel with 0.113. On the other hand, the traditional interest rate channel and the credit investment channel have very large p-values, i.e. they do not Granger-cause

[31] This is consistent with Runkle (1987) who finds that only 4 per cent of the variance in output is explained by innovations in money—as he puts it, *"These results suggest that money has little effect on output"*.

[32] Sims (1980) result also shows that including interest rate reduces the explanatory power of money innovation on output to less than 10 per cent.

Table 7.2.15 Granger-causality test
dependent variable: Real output (DGDPR)

Interest rate channel				***Exchange rate channel***			
Exclude	Chi-sq	df	Prob.	Exclude	Chi-sq	df	Prob.
DM1	3.513	7	0.834	DM1	3.057	7	0.880
DINT	3.394	7	0.846	DINT	7.408	7	0.388
DKF	4.431	7	0.729	DEXCH	11.106	7	0.134
				DEXP	15.860	7	0.026
All	11.899	21	0.942	*All*	37.794	28	0.102
Other asset price channel				***Credit-investment channel***			
Exclude	Chi-sq	df	Prob.	Exclude	Chi-sq	df	Prob.
DM1	4.459	5	0.485	DM1	1.809	5	0.875
DPE	9.311	5	0.097	DCRED	1.983	5	0.852
DPCE	18.768	5	0.002	DKF	7.129	5	0.211
All	32.230	15	0.006	*All*	12.131	15	0.669
Credit-consumption channel							
Exclude	Chi-sq	df	Prob.				
DM1	1.950	5	0.856				
DCRED	2.239	5	0.815				
DPCE	15.855	5	0.007				
All	21.803	15	0.113				

output. This provides another empirical justification for researchers dissatisfaction with the traditional interest rate channel, i.e. it seems that past values of investment cannot explain changes in output while private consumption and exports show very significant Granger-causal effect. This result is quite the opposite of the finding of the previous variance decomposition analysis that shows fixed investment shock as the most significant shock in explaining the variance of output. This is likely caused by the fact that the contemporaneous correlation between investment and output[33] (which the impulse response function and the forecast error variance decomposition depend on) is much higher than the correlations between output and past (or lagged) values of investment—which the Granger-causality test depends on. In other words, because of the exclusion of the contemporaneous values of the explanatory variables in the Granger-causality test its results and conclusions may be different to that of the variance decomposition analysis.

[33] The contemporaneous correlation is 0.41 whereas the correlation between output and the first lagged values of investment is 0.23, and the second lagged values is just 0.14.

On an individual basis, the two variables showing the most significant Granger-causal effect on output are: private consumption and exports. The money supply and the interest rate, on the other hand, do not Granger-cause output[34]. This finding is consistent with that of Taylor (1997) who finds output Granger-causing money supply and other variables.

Summary

As in the previous neutrality test analysis where the results of the bivariate models were found to be generally the same as those in the trivariate VAR model, we see here the same pattern, i.e. the results of the bivariate models are generally repeated in the larger VAR models[35]. The exceptions occur however when the 'extra' variables have high correlations with the other variables in the models or if the number of lags used in the models are significantly different. We also note the empirical support for the concept of the serial transmission mode when we tested it on a few variables. However when we compare the responses of the direct transmission approach with that of the serial and parallel approaches we find there is great discrepancy in both the magnitude and the lag-periods, i.e. there seems to be no single transmission model that fits well with that of the 'encompassing' model. This provides further empirical evidence that the process in-between the monetary policy implementation and the response of output is very much a 'debatable' issue. It is quite clear also that interest rate leads money supply—at least there is no' liquidity 'puzzle' when the source of shock comes from interest rate. One puzzling observation is the relatively small impact of interest rate shock on fixed investment but as explained in the analysis, foreign investment seems to provide an explanation to this—at least the studies cited report great importance of foreign investment on fixed capital formation in New Zealand since 1990. Using the response summary statistics, the credit channels are found to be very important conduit of monetary impulse, in particular the credit-consumption channel. However, when the source of shock is interest rate, both the traditional interest rate channel and the exchange rate channel become more significant. In the analysis of the response and variance decomposition, fixed investment is found to be the most influential variable on output, however according to the Granger-causality test, export and private

[34] Hayo (1999) in his cross-country study finds evidence that support Granger-causality running from output to money and vice versa. As he puts it: *But more general statements about money-output causality cannot really be supported.*

[35] In their robustness test, Favara and Giordani (2002) added extra variables to their original VAR model but they found no significant difference in the results--as they put it: *No appreciable differences in the results.*

consumption are more important. In fact the traditional interest rate has the lowest Granger-causal effect on output. The exchange rate and the credit-consumption channels, on the other hand, have the largest Granger-causal effect. The discrepancy in the conclusions of the impulse response analysis and the Granger-causality test is due to the fact that while there is contemporaneous relationship in the former, in the latter the dependent variable depends only on the lagged values of the explanatory variables. The fact that fixed investment has a relatively large influence on output, and that most of it is funded from abroad, would imply that external shocks could have significant effect on New Zealand output. This would seem to be consistent with Conway (1988) who finds that a considerable share of variability in New Zealand macroeconomy is due to external or foreign shocks. In terms of the lag-period, i.e. the time it takes for the monetary impulse to reach output, the interest rate channel and the credit-investment channel have the shortest lag-period of about five quarters and the longest lag is that of the exchange rate channel with a lag-period of ten quarters (over 2 years). This extended lag-period is largely due to the extended impact of exchange rate shock on export (about 7 quarters). In times of high exchange rate this may be unfavourable to New Zealand exports and this is why New Zealand exporters usually hedge their exports[36]. In analysing the responses of output from the different transmission channels, as well as from the encompassing model, the pattern and the magnitude of the responses are quite different. The difference is also observed when the source of shock is different (i.e. money supply or the interest rate). In the encompassing model, for instance, output shows quite a large immediate response to money supply shock—the first significant response is in the 1st quarter after the shock and is about 10 per cent and another one in the 4th quarter—around 6 per cent. Output response to interest rate shock on the other hand starts in the 3rd quarter (just over 6 per cent) but remains relatively significant for the next three or so quarters. After the 5th quarter, output responses from the two shocks seem to converge with the interest effect dominating the money supply effect[37]. This shows that money supply increase has a very immediate impact on output but in the longer term, the interest rate effect seems to dominate. Apart from the response in the first quarter, the peak response of output to both shocks is about the same—roughly 6 per cent.

[36] As noted by Armstrong, *"Hedging by a lot of companies (particularly Fonterra) has sheltered New Zealand from the worst effect of the currency's rise"*.

[37] Runkle (1987) also noted that innovations in nominal interest rates rather money are the driving force behind movements in both money and industrial production (output).

What this section reveals is that the different channels are quite unique in their response and variance decomposition pattern. The results also demonstrate that the Granger-causality results are not always consistent with the innovation accounting (impulse response and the variance decomposition) findings.

The question as to whether the results obtained in this analysis hold across other countries[38] will be addressed in our next analysis that will look at the monetary transmission mechanisms in Australia.

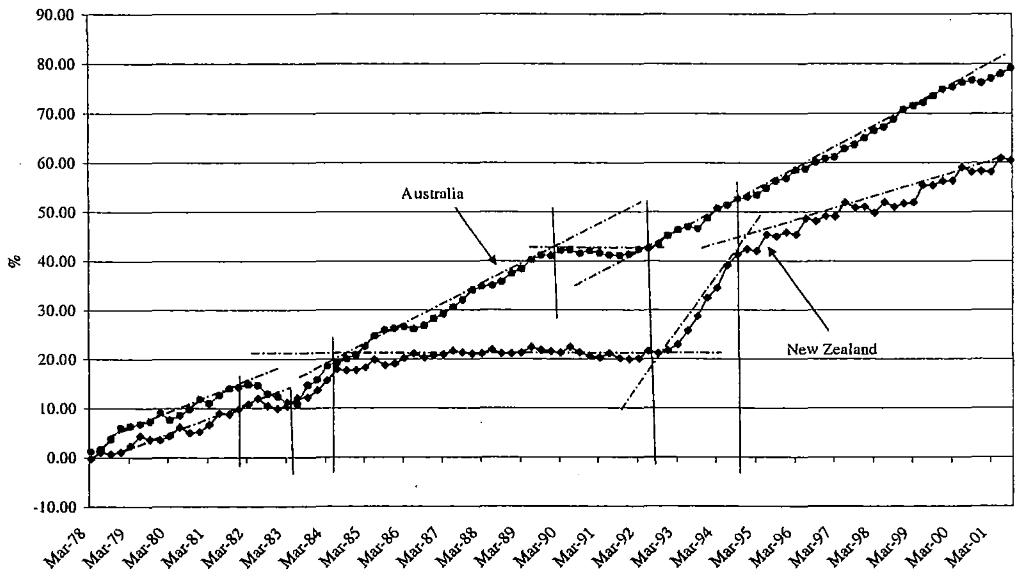
[38] As aptly put by Hayo (1999): *One important lesson to draw from this conclusion is that concentrating research on one country, here the US, does not help very much in assessing general questions connected with Granger-causality. For instance, the specific claim that made by Davis and Tanner (1997) that money still causes economic activity when appropriately adjusting the time period is likely to be correct only in the context of the US economy.*

7.3 Comparison between Australia and New Zealand transmission mechanisms

7.3.1 Brief overview

This chapter compares the monetary transmission channels in Australia and New Zealand. One motivating factor behind this is the fact that New Zealand's real output levelled off since the mid 1980s for almost a decade—unlike Australia's output that continued to grow almost uninterrupted in the same period. The question is: *Can the monetary transmission process explain this difference?*

Fig 7.3.1 GDP growth rates of Australia and New Zealand: 1978-2001



Note: These are the cumulative growth rates of real GDP with the same starting date and the lines drawn are meant to highlight the different trends—they are simple approximations, i.e. not based on rigorous statistical analysis.

In order to carry out meaningful comparison between the two countries, we need to employ the same analytical techniques we used in the previous analysis. These techniques include VAR impulse response functions, variance decompositions and the Granger-causality test[39]. However before carrying out the analysis, it is useful to see how the two monetary policy tools (money supply and interest rate) move in both countries. These are shown in Figure 7.3.2.and Figure 7.3.3.

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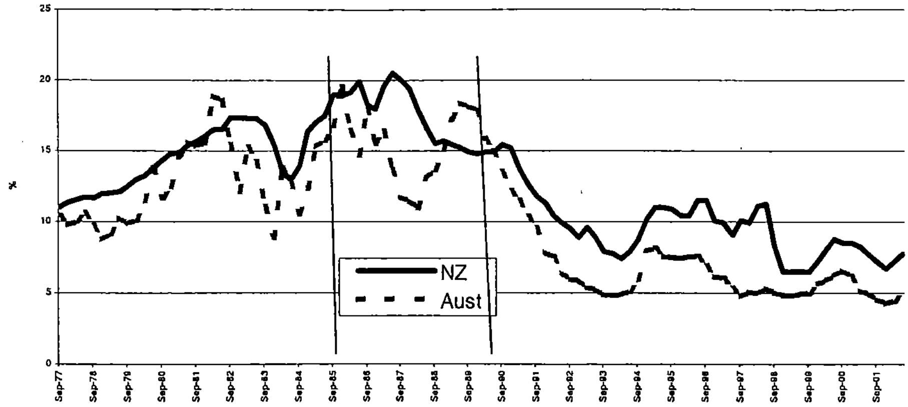
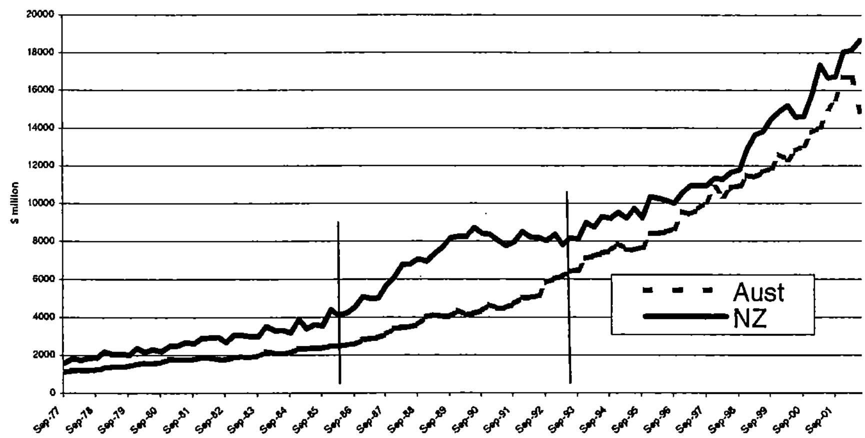
[39] The approach here is slightly to that of Britton and Whitley (1997) who compared the monetary transmission mechanisms in France, Germany and the United Kingdom, to see whether the 'structural' differences in the countries have important implications for the transmission of monetary policy onto output and inflation.

Fig 7.3.2 Interest rates in Australia and New Zealand



Notes: These are the nominal interest rates; the vertical lines are just to mark the period where the interest paths seem to diverge; For Australia, the interest rate is the interest on the 90-day bill whereas the New Zealand interest rate is the mortgage rate.

Fig 7.3.3 Monetary aggregates (M1) in Australia and New Zealand



Note: Australian actual data has been divided by 10 in order to show the two series on the same scale.

From the two figures above it is obvious that the variables from the two countries tend to move together except for the period (of almost a decade) starting in the mid 1980s. In particular the interest rates of the two countries in this period seem to move opposite to each other. If we assume the monetary policy to be conducted through interest rate then the difference observed implies that the monetary policy in the two countries became very different in the mid 1980s with New Zealand maintaining a very tight monetary policy while Australia did actually the opposite[40]. This is quite an important and revealing observation but the comparison is based on historical pattern and therefore is open to any kind of interpretation[41]. To address this issue we need some kind of dynamic simulation that could reproduce or show the alternative scenario had interest rates in both countries followed the same trend throughout the period of study. This simulation will be conducted in the latter part of the analysis. First we need to compare the transmission models in both countries to see whether there is any important difference in the way monetary impulse is being transmitted to real output. The transmission channels for New Zealand have been estimated in the previous analysis so the following impulse responses, variance decompositions and the Granger-causality test results pertain to Australia only.

7.3.2 Comparison of the impulse responses

Table 7.3.1 shows the responses of the bivariate relationships within each transmission model and is the counterpart of Table 7.2.8 in the previous analysis. Note there is no bivariate model estimated this time—i.e., all the bivariate relationships in this section come from the 'parallel' VAR models. This is because the impulse responses and the decompositions are generally the same in the two transmission modes.

Looking at the response of interest rate to money supply shock (DINT/DM1) in the first column of both the interest rate channel and the exchange rate channel we see all positive responses except for the two small negative responses in the 9th and 10th quarters in the interest rate channel. The positive responses are known in the literature as the 'liquidity' puzzle. In New Zealand the corresponding responses in the first two quarters are negative, then positive for five quarters before becoming negative again (see Table 7.2.8). What this suggests is that following a monetary expansion, policy makers in Australia immediately raise the interest rate as to reduce possible inflationary pressure[42] but in New Zealand the policy makers seem to wait for some time (two quarters) before they raise their interest rate.

[40] It is interesting to recall here the monetary deflationary policy of Reagan (US) and Thatcher (UK) around the same period which resulted in deep recessions in both countries (see Snowdon et al., 1994, p. 203).
[41] Cagan (1993) in fact refers to Friedman and Schwartz (1963) finding that money causes activity as not very conclusive because they based their analysis on historical patterns of the variables comovements.
[42] Note the assumption here is that monetary expansion is related to increase in inflation rate.

Table 7.3.1 Aust: Impulse responses based on the parallel transmission mode

Interest rate channel				***Exchange rate channel***				
Lags	DINT/DM1	DKF/DINT	DGDPR/DKF	Lags	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
1	0.122	0.011	0.071	1	0.103	0.136	-0.243	-0.003
2	0.116	0.046	0.002	2	0.185	0.048	0.119	-0.017
3	0.203	-0.164	0.033	3	0.156	0.021	0.123	0.001
4	0.037	0.052	0.004	4	0.048	-0.126	0.101	0.008
5	0.111	-0.071	0.014	5	0.121	-0.061	-0.247	-0.046
6	0.094	-0.073	-0.025	6	0.114	0.009	0.021	0.017
7	0.007	0.009	-0.002	7	0.101	-0.009	0.009	0.005
8	0.030	0.005	-0.023	8	0.067	0.065	0.067	0.019
9	-0.016	0.025	-0.002	9	0.035	-0.006	0.042	-0.002
10	-0.008	0.027	-0.017	10	0.080	-0.014	-0.041	0.012

Other asset price effects channel				***Credit-investment channel***			
Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	Lags	DCRED/DM1	DKF/DCRED	DGDPR/DKF
1	0.114	0.115	-0.001	1	0.107	0.140	0.050
2	-0.140	-0.031	-0.022	2	0.115	0.097	0.026
3	0.259	0.153	0.055	3	0.220	-0.168	0.029
4	-0.148	0.249	-0.021	4	0.145	0.003	0.013
5	0.058	-0.032	-0.030	5	0.151	0.016	-0.008
6	-0.035	0.165	0.032	6	0.219	-0.060	0.002
7	0.096	0.119	-0.012	7	0.250	0.178	-0.009
8	-0.137	0.026	-0.002	8	0.215	-0.068	-0.018
9	0.106	0.132	0.020	9	0.229	0.021	-0.009
10	-0.091	0.097	-0.010	10	0.206	0.044	-0.015

Credit-consumption channel			
Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE
1	0.120	0.255	-0.010
2	0.102	0.106	-0.018
3	0.156	0.064	0.051
4	0.123	0.074	-0.035
5	0.144	0.231	-0.032
6	0.208	0.047	0.043
7	0.195	0.114	-0.022
8	0.219	0.125	0.008
9	0.248	0.054	0.020
10	0.226	0.080	-0.018

Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1 refers to the response of interest rate to money supply shock, and DKF/DINT refers to the response of fixed capital formation to interest rate shock, etc.

There is also some difference in the magnitude of the responses—for example, in New Zealand the peak response is 32 per cent and occurs in the 6th quarter but in Australia it is 20 per cent and occurs in the 3rd quarter. In short, policy makers in New Zealand tend to react belatedly to inflationary pressure but their response is fairly strong and short-lived[43] whereas policy makers in Australia tend to act more quickly but in a more mild and sustained fashion. Interestingly, this assertion about the reaction in New Zealand seems to collaborate well with Armstrong (2004) recent comment on the belated response of the Reserve Bank of New Zealand in increasing the interest rate. To quote his words: *"The chance that the optimists (in the housing sector particularly) might proven right was destroyed last week when Bollard* (The Reserve Bank Governor*) unexpectedly raised the interest rate. Close watches of the Reserve Bank believe Bollard regretted not raising the rates in December and that he will increase interest rates two times before June as he tries to make up for the lost time".*

Another interesting observation is the significant response of fixed investment to both the interest rate (of 16 per cent) and the credit shock (of 18 per cent) in Australia—unlike the weak response noted in New Zealand of less than 10 per cent. This would suggest that investment in Australia depends to a great extent on domestic borrowings[44] while New Zealand's investment is more likely to be funded from open market bonds or by overseas investors—which is not unusual for small open economies like New Zealand.

In terms of the demand aggregates (e.g. investment and private consumption) impact on output, figures for Australia show lower magnitude than the corresponding figures in New Zealand. For example, from Table 7.3.1 output peak response to fixed investment shock is 7 per cent whereas in New Zealand the corresponding figure is over 20 per cent (see Table 7.2.8). With respect to private consumption impact on output, the maximum response in Australia is 5 per cent and occurs in the 3rd quarter but in New Zealand it is 15 per cent and occurs in the 1st quarter. This clearly indicates that investment and private consumption in New Zealand have immediate and more significant impact on output than in Australia.

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[43] Friedman (1968) refers to this kind of belated but strong response as "Too late too much". He continued on and said: *The reason for the propensity to overreact seems clear: the failure of monetary authourities to allow for the delay between their actions and the subsequent effects on the economy.*

[44] This is somewhat confirmed by Suzuki (2001) who reports, *"The Australian corporate sector makes little use of direct forms of financing. At the end of September 2000, the ratio of outstanding short-term securities issued by the private non-financial corporate sector ...... to outstanding bank loans to the same sector is 16.9%. As such there are many bank dependent borrowers in Australia".*

Unlike other channels, the exchange rate channel seems to have several quarters that show quite significant responses. For instance, in Australia the significant responses of exports following exchange rate shock occur in the 1st quarter (- 24 per cent) and in the 5th quarter (-25 per cent) while in New Zealand the corresponding responses occur in the 3rd quarter (-17 per cent) and in the 7th quarter (-21 per cent). This multiple-peak response of exports to exchange rate shock may be explained by the fact that 'international competitiveness' does not depend on just exchange rate devaluation alone—other important factors affecting exports include domestic and overseas inflation rates, output, as well as monetary policy itself. These economic variables could have different timing patterns or cycles hence their impact on exports may be varied.

The more immediate impact of the exchange rate shock on exports in Australia would seem to suggest that exporters would easily cut back their exports when the exchange rate is unfavourable to them. Another interpretation is that Australian export markets elasticity of demand with respect to exchange rate for Australian goods is highly elastic[45]. This is unlike New Zealand where exporters keep on exporting for some time (say for six quarters) after currency appreciation, i.e. exports seem to be more inelastic to exchange rate increase in New Zealand. This would imply that New Zealand is more prone to adverse impact of exchange rate appreciation than Australia, at least in terms of exports[46]. This may be explained by the relative smallness of New Zealand compared to Australia both in terms of the economy and the population, i.e. the larger Australian domestic economy is able to absorb the 'unwanted' exports[47] whereas New Zealand could not. The New Zealand exporters however would be 'shielded' by their fixed price contracts or by their foreign exchange hedging strategy but if the exchange rate remains long enough at a relatively high rate, then exporters may face serious problems eventually[48]. How long this duration would be? Well, according to Table 7.2.1 and Table 7.2.8, the impact could be felt in the 3rd

[45] Roos (2000) also reported the high output elasticities of demand of the US and Japan for Australia's exports.

[46] One way New Zealand exporters mitigate the adverse impact of high exchange rate is to have contracts that fix the price of their exports in New Zealand dollars or by using foreign exchange 'hedging' (Reserve Bank of New Zealand, 2003).

[47] This refers to the production that is generally earmarked for exports but because of high exchange rate is now locally consumed.

[48] This situation is echoed by Armstrong (2004) who said, "*With hedges running out and the dollar still rising, there will be likely huge hardship in the export sector next year.*

quarter or in the 7th quarter. The impact of the latter is much more severe, i.e. the exports would decline by 21 per cent compared to the decline of 17 per cent in the 3rd quarter.

The response of nominal exchange rate to interest rate shock in New Zealand is much higher than the corresponding figure for Australia. For example, in New Zealand the peak response of 28 per cent is observed in the 4th quarter whereas in Australia the peak response of just 14 per cent is noted in the 1st quarter[49]. This would suggest that New Zealand's economy is more 'open' to capital movements from abroad than that of Australia following a change in interest rate. Obviously the downside of this high exchange rate elasticity is that any monetary tightening in New Zealand will mean an immediate rise in exchange rate which could make New Zealand 'international competitiveness' worse off if the domestic inflation either remains constant or does not decrease[50]. This is an important issue for New Zealand and other countries that focus exclusively on low inflation-targeting because by their very act of tightening monetary policy to contain inflation, they probably end up having high real exchange rate and unfavourable international competitiveness, not mentioning the more direct adverse effect of high interest rate on investment spending.

The probable reason for the weaker impact of the interest rate shock on the exchange rate in the case of Australia is that there are other factors other than the interest rate that might be influencing the exchange rate, such as the current account deficit, the inflation rate, the investment environment and the speculative activities (see, for example, Blundell-Wignall et al. (1993)).

Looking at the response of private consumption and fixed investment to the domestic credit shock, in New Zealand the peak responses occur in the 9th and 7th quarters (see Table 7.2.8), respectively. In contrast, in Australia the peak response are noted much earlier. For instance, in the case of the fixed investment response to credit shock, in the 1st quarter the response is 14 per cent and the next peak response of 18 per cent is noted in the 7th quarter. And the peak response of private consumption to credit shock (of 26 per cent) is seen in the 1st quarter. This would suggest that if there is a credit crunch then New Zealand would not be greatly affected as much as Australia. Putting it differently, a recession in New Zealand

[49] The immediate impact of the change in the cash rate on exchange rate is also noted by Dungey (2001).
[50] This could be serious in the case of New Zealand which already has very low inflation rates.

will hardly be caused by any credit crunch whereas in Australia it could spell the beginning of a recession.

In order to see which transmission channel, as a whole, is more effective in terms of the larger summary response and shorter lag-period, Table 7.3.2 and Table 7.3.3 are constructed like Table 7.2.9 and Table 7.2.10 in the previous analysis.

Table 7.3.2 Aust: Total lags and summary responses
(traditional channels)

Transmission channels	*No.of Lags*	*Summary response*
Interest rate channel	13	0.0002 (0.02%)
Exchange rate channel [(a)]	8	0.0006 (0.06%)
Other asset price channel	10	0.0035 (0.35%)
Credit-investment channel	15	0.0022 (0.22%)
Credit-consumption channel	13	0.0032 (0.32%)

[(a)] This excludes the 'DINT/DM1' column –because there is no negative value.

Table 7.3.3 Aust: Total lags and summary responses
(modified channels)

Transmission channels	*No.of Lags*	*Summary response*
Interest rate channel [(b)]	4	0.0116 (1.16%)
Exchange rate channel[(b)]	8	0.0006 (0.06%)
Other asset price channel	13	0.0042 (0.42%)
Credit-investment channel	11	0.0006 (0.06%)
Credit-consumption channel	13	0.0020 (0.20%)

Note: Table 7.3.2 refers to the 'traditional' channels (i.e. with money supply as the starting point of the monetary impulse) and Table 7.3.3 uses interest rate as the starting point for the monetary impulse.
[(b)] The DINT/DM1column is ignored.

Looking at the numerical values of the summary responses in the tables there is some broad consistency in the magnitudes and the relative positions of the different transmission channels between the two countries. However there are a few notable differences. The first is the smaller summary response of the credit-consumption channel in Australia of 0.32 per cent compared to New Zealand figure of 1.44 per cent[51]. Another difference is the summary response of the exchange rate channel—for example, in New Zealand (see Table 7.2.10) the

[51] This seems to be consistent with Suzuki (2001) finding that the 'lending channel' of monetary policy in Australia is not supported by empirical analysis.

value is 0.25 per cent but in Australia the corresponding figure is only 0.06 per cent. In other words, there is potential for the exchange rate channel in New Zealand to be more effective than in Australia in transmitting interest rate shock to output. However the lag-period in New Zealand seems to be more extended than in Australia.

Among the transmission channels in Australia, the 'other asset price effects' channel shows the largest summary response of about 0.4 per cent[52]. The interest rate channel on the other hand shows relatively low summary response when money supply is the source of shock but when the source is the interest rate the channel shows the largest response (of 1.16 per cent) and the shortest lag-period of four. This is consistent with the evidence from New Zealand that shows a relatively large summary response of 2.39 per cent and the lag period of five.

In terms of the lag periods, most transmission channels in Australia, except the exchange rate channel, have longer lags than the channels in New Zealand. This longer lag could pose some problems to monetary policy makers in Australia because as Uselton (1974) noted *"a long or highly variable lag might imply that discretionary stabilization policy is ineffective or, at worse, counterproductive"*. However, looking at Table 7.3.1 we see that the two credit channels have several large responses that are almost the same and so it is quite difficult to decide which is the peak or maximum response. It is also important to note that when the source of shock is the interest rate, both the interest rate channel and the exchange rate channel from Australia have shorter lag-period. In view of these problems and inconsistencies, any comparison or interpretation with respect to the lags of the transmission channels across the two countries should be done with great caution.

7.3.3 Comparison of the variance decompositions

The variance decompositions of the five monetary transmission models for Australia are shown in Table 7.3.4. This is the counterpart of Table 7.2.11 that shows New Zealand variance decomposition results.

[52] This is roughly the same as the summary response for New Zealand but the individual components (see Table 7.2.8 and Table 7.3.1) are quite different.

Table 7.3.4 Aust: Variance decompositions (%)

	Interest rate channel			*Exchange rate channel*			
lags	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
1	1.96	0.01	16.81	11.85	1.57	2.97	2.34
2	3.37	0.20	13.94	34.05	1.24	3.60	2.15
3	6.89	2.46	14.40	26.75	1.55	4.11	2.54
4	6.87	2.56	14.35	27.88	1.52	5.37	3.22
5	7.23	2.83	13.81	25.40	1.47	8.37	9.97
10	7.72	3.10	15.06	23.70	1.55	14.77	13.28
20	7.88	3.14	14.99	23.95	1.70	15.34	14.91
30	7.96	3.13	15.18	23.95	1.71	15.37	14.89
40	8.02	3.13	15.35	23.95	1.71	15.37	14.89

	Other asset price channel			*Credit investment channel*		
Lags	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF
1	1.29	1.74	0.00	4.15	2.65	8.90
2	2.98	1.85	1.63	6.31	2.65	8.46
3	8.34	4.59	9.64	13.79	4.69	8.99
4	9.91	8.98	10.65	14.56	4.52	8.77
5	9.73	8.74	12.03	15.79	4.22	8.41
10	12.48	11.12	13.31	28.59	6.50	8.90
20	13.98	11.79	14.03	36.19	6.96	9.53
30	14.88	12.10	13.64	37.32	7.31	9.66
40	15.22	12.27	13.52	38.16	7.53	9.80

	Credit-consumption channel		
Lags	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE
1	6.31	9.00	0.38
2	6.98	9.79	1.47
3	10.23	10.19	9.16
4	10.63	9.34	11.97
5	11.80	13.31	13.50
10	27.93	13.29	17.05
20	47.61	13.24	18.03
30	54.24	13.17	17.29
40	57.91	13.35	16.91

Notes: (i) All the variables are in first difference—hence the 'D' prefix.
(ii) To read the table, DINT/DM1 stands for the proportion of interest rate variance explained by money supply shock, and similarly, DKF/DINT stands for the proportion of fixed capital variance explained by interest rate shock.

In Australia the three demand aggregates (investment, exports, and private consumption) shocks explain less than 20 per cent of output variance whereas in New Zealand fixed investment shock explains over 40 per cent of output variance—the other two aggregates (i.e. private consumption and exports) have similar explanatory power as the aggregates in Australia. This clearly highlights the relative importance of fixed investment in New Zealand as the main driving factor behind output variability while in Australia all the three demand aggregates seem to have roughly the same influence on output variability.

Another notable difference in the variance decompositions between the two countries is the relatively large proportion of credit variance that is explained by money supply shock in Australia compared to New Zealand. For instance, in the credit-investment channel the proportion of credit variance explained by money supply shock is 38 per cent compared to 12 per cent in New Zealand. Likewise, in the credit-consumption channel the figure for Australia is 58 per cent and for New Zealand it is only 17 per cent. The interest rate, on the other hand, can explain only 9 per cent of the credit variance in Australia and only 2 per cent in New Zealand (note these are not reported in the tables because the models use the money supply rather than the interest rate as the starting point of the transmission process). This would suggest that if we want to investigate the credit channel impact on real output (or inflation), the source of shock should be the money supply because the interest rate changes would not have much impact on the credit aggregate.

Comparing the effect of interest rate shock on exchange rate variance we see that in New Zealand it is 14 per cent but in Australia it is less than 2 per cent. This result is consistent with the result of the response analysis that shows higher response of exchange rate to interest rate shock in New Zealand compared to the corresponding response in Australia.

7.3.4 Comparison of Granger-causality test results

Table 7.3.5 shows the Granger-causality test results for Australia, i.e. the counterpart of Table 7.2.12 in the previous analysis.

As noted in the analysis of New Zealand data, most of the causal orderings as postulated in each transmission channel are not significant, i.e. the past values of the explanatory variables do not seem to Granger-cause the dependent variables. In some cases there is evidence of reverse-causality. This pattern seems to be the same for Australia as well. For instance, from Table 7.3.5 we see that interest rate does not Granger-cause fixed investment—instead fixed investment Granger-causes interest rate. Reverse causality is also observed for the interest rate-exchange rate (DEXCH/DINT) relationship, i.e., instead of interest rate Granger-causing exchange rate, it is the exchange rate that is actually Granger-causing interest rate. This is different though in New Zealand where the interest

Table 7.3.5 Aust: Granger-causality test results (p-values)

Interest rate channel				***Exchange rate channel***			
	DINT/DM1	DKF/DINT	DGDPR/DKF	DINT/DM1	DEXCH/DINT	DEXP/DEXCH	DGDPR/DEXP
Normal	0.431	0.734	0.367	0.074	0.904	0.199	0.326
Reverse	0.563	0.013	0.918	0.158	0.004	0.408	0.780
Other asset price channel				***Credit-investment channel***			
	DPE/DM1	DPCE/DPE	DGDPR/DPCE	DCRED/DM1	DKF/DCRED	DGDPR/DKF	
Normal	0.234	0.490	0.109	0.596	0.090	0.286	
Reverse	0.359	0.439	0.276	0.052	0.699	0.808	
Credit-consumption channel							
	DCRED/DM1	DPCE/DCRED	DGDPR/DPCE				
Normal	0.810	0.180	0.125				
Reverse	0.544	0.088	0.644				

Notes: To read the table, the entries along the row labelled 'normal' refer to the causal orderings as hypothesized in the transmission models. For example, under the 'DINT/DM1' heading, in the 'normal' row, we see a p-value of 0.431. This means that there is no significant Granger-causal effect of money on interest rate, i.e. the dependent variable is interest rate and the money supply (DM1) is the explanatory variable. The 'reverse' row shows p-values when the causal direction is reversed, for instance, 0.563 under DINT/DM1shows the p-value of the Granger-causality effect of interest rate on money supply.

rate does not Granger-cause the exchange rate nor the exchange rate Granger-causes the interest rate. This would suggest that in Australia the monetary policy via the interest rate responds to past exchange rates, i.e. it is endogenous to exchange rate movements, but in New Zealand the relationship is more likely to be contemporaneous.

Another important Granger-causal relationship is between that of fixed investment and credit in the credit-investment channel. From the table above we see that the credit variable Granger-causes investment at the 10 per cent significance level but in New Zealand (see Table 7.2.12) this is not significant. This confirms Australia's reliance on credit to finance fixed investment—unlike New Zealand whose investment seems not to depend on domestic interest rate nor on credit availability.

As to the credit-consumption channel, the results in Table 7.3.5 show that the channel is generally not significant. In contrast, the results from the New Zealand data (see Table

7.2.12) show that this channel is significant. In particular there is a very significant Granger-causal effect of money supply on domestic credit and of private consumption on output.

7.3.5 Direct transmission analysis

Our analysis so far has focused on the sequential framework of the monetary transmission mechanisms, i.e. we have tried to follow the ordering of the variables as stipulated in each transmission mechanism. Our next analysis will focus on the direct impact of monetary shock on real output. This would be more in line with most VAR studies that simply look at the response of output (or inflation) following money supply or interest rate shock without investigating the 'intermediate' steps as done in this study. The results and data from the 'parallel' VAR models used in the previous analysis will be used here as well.

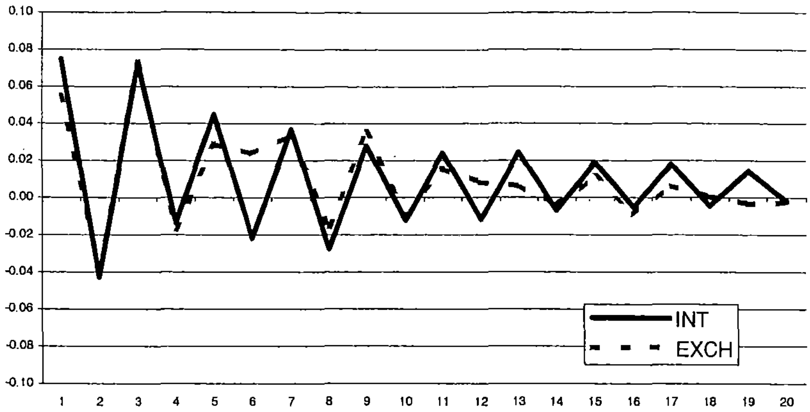
Impulse response analysis

The output responses following money supply shock of the different transmission channels are shown in Fig 7.3.4 and Fig 7.3.5. The corresponding figures for New Zealand are shown in Fig 7.2.6. The responses here are grouped together because of their similarity—unlike the responses for New Zealand whose patterns are fairly unique.

From Fig 7.3.4 and Fig 7.3.5 we see that output movements following money supply shock has generally the same pattern peaking in the 1^{st}quarter, 3^{rd} quarter, and every two quarters thereafter—unlike output responses in New Zealand which peak in different quarters and having no regular or systematic pattern.

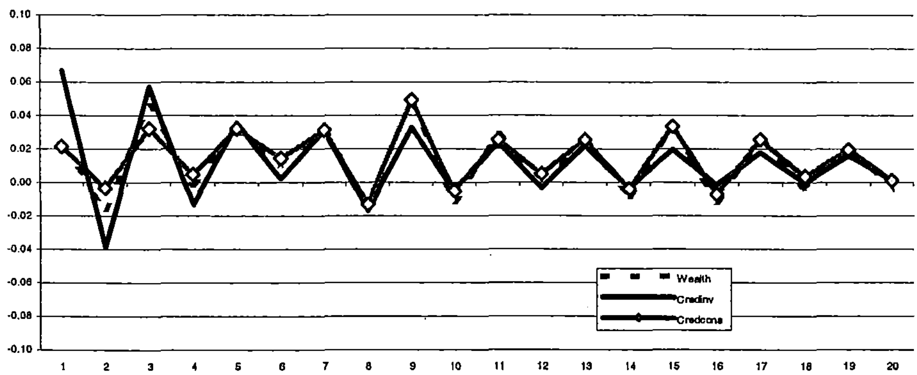
The output peak response in the interest rate channel is 7 per cent. In the other channels the peak responses are around 5 per cent and most occur in the 1^{st} and 3rd quarter except the credit-consumption channel in which the peak response occurs in the 9th quarter. In New Zealand, the maximum responses are also less than 10 per cent with the interest rate channel showing the highest response (of over 8 per cent) followed by the 'other asset price effects' channel response with 6 per cent.

Fig 7.3.4 Aust: Output response to money supply shock
(interest rate and exchange rate channels)



INT = Interest rate channel; EXCH = Exchange rate channel

Fig 7.3.5 Aust: Output response to money supply shock
(other asset price, credit-investment and credit-consumption channels)



Wealth = Other asset price effects (consumption wealth) channel
Credonv = Credit-investment channel
Credcons = Credit-consumption channel

The next set of graphs (Fig 7.3.6) shows output response to interest rate shock for each of the different transmission model. Because of the negative correlation between interest rate and output, we will focus on the negative responses of output to interest rate shock, so when we refer to a peak response, we are generally referring to the negative peak response.

From Fig 7.3.6 we see that output response following interest rate shock has a more distinctive or unique response pattern. We also note the relatively small responses this time, i.e. most responses are 2 per cent or less. However, this magnitude is slightly higher than most responses that have been reported by other studies. For example, Brischetto and Voss

(1999) find that a contraction of monetary policy results in 0.2 per cent decline in output between 5 and 15 quarters. Gruen et al. (1999), on the other hand, find that a one percentage point rise in interest rate causes output to decline by 'one third per cent each year' i.e. about 0.33 per cent, and the lag-period is 5-6 quarters. Gruen regressed output on short-term real interest rate, US output, and on its own lags. And Suzuki (2001), using a VAR model with eight variables, reports only 0.02 per cent as the impact of cash rate innovation (of 0.47 percentage point) on output in the 16 quarters.

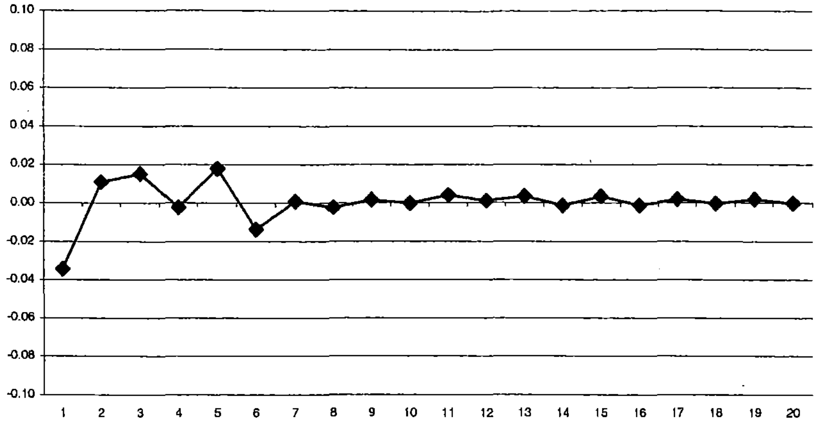
From the interest rate channel, Fig 7.3.6(a), we see output declines initially in the first quarter by almost 4 per cent after interest rate shock but then in the 2nd quarter it starts to rise and remains positive for the next two or three quarters. By the 6th quarter it declines by about 2 per cent after which it returns to equilibrium. The initial decline in output would suggest that output is fairly responsive to interest rate but only temporarily because it is not sustained. The pattern observed here is quite different to the pattern observed for New Zealand that shows quite significant and sustained negative responses in the first few quarters (see Fig 7.2.7(a)).

As to the exchange rate channel we see negative responses in the first two quarters, then a relatively significant but positive one in the 3rd quarter followed by another negative response. The positive response in the 3rd quarter coincides with the peak response following money supply shock (see Fig 7.3.4). Thus it would seem the positive impact of money supply shock on output is fairly robust and dominating. In New Zealand the peak responses are mostly negative and significant (see Fig 7.2.7(b)) implying a stronger effect of interest rate on output.

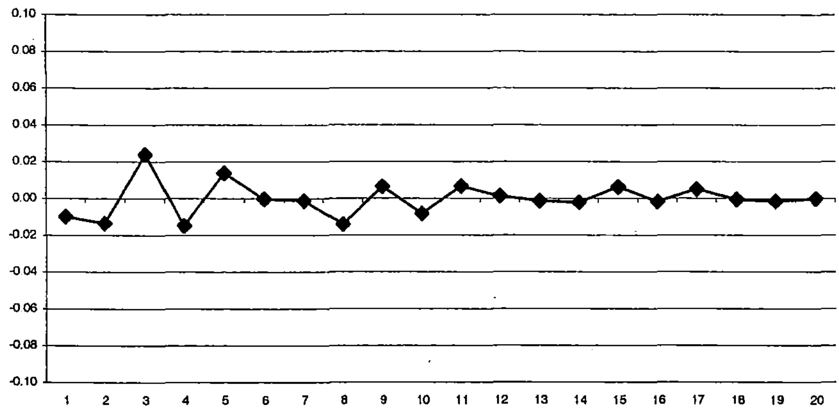
Of the two credit channels, the credit-consumption channel shows slightly higher output response than the credit-investment channel, in particular two distinct peak responses (of roughly 2 per cent) can be seen in the 3rd and 7th quarter in the former whereas in the latter only one peak response is noted in the first quarter. The 'other asset price effects' channel also shows some significant response especially in the 9th and 11th quarters. All the responses however are generally 2 per cent or less, i.e. less than the responses due to money supply shock.

Fig 7.3.6 Aust: Output response to interest rate shock

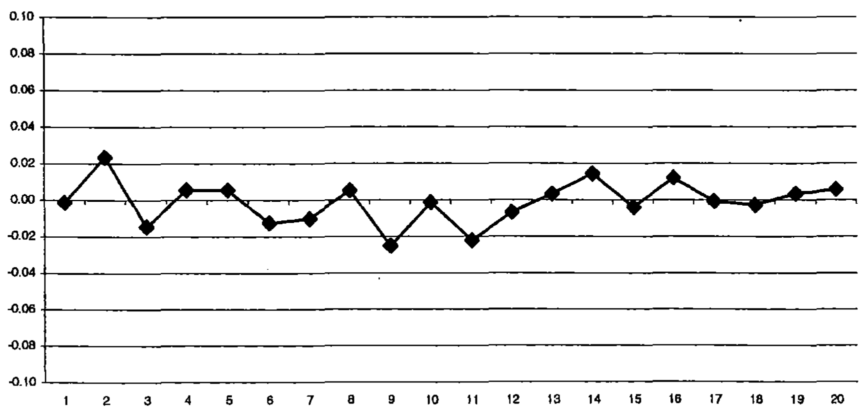
(a) ***Interest rate channel***



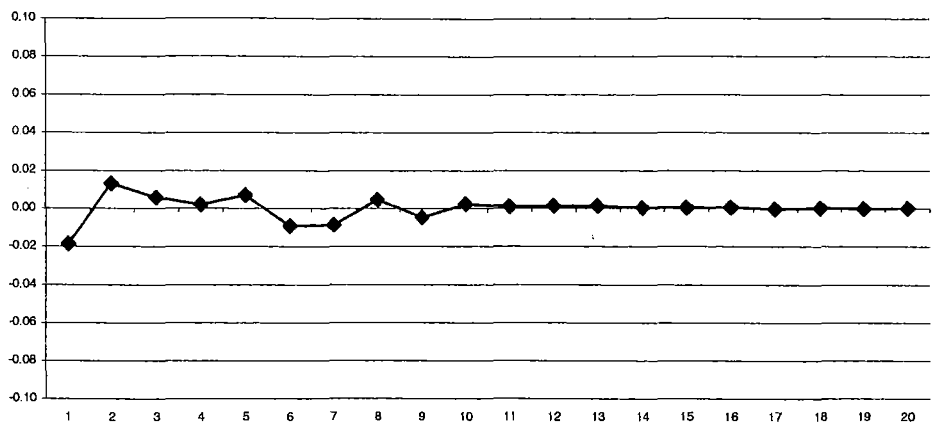
(b) Exchange rate channel



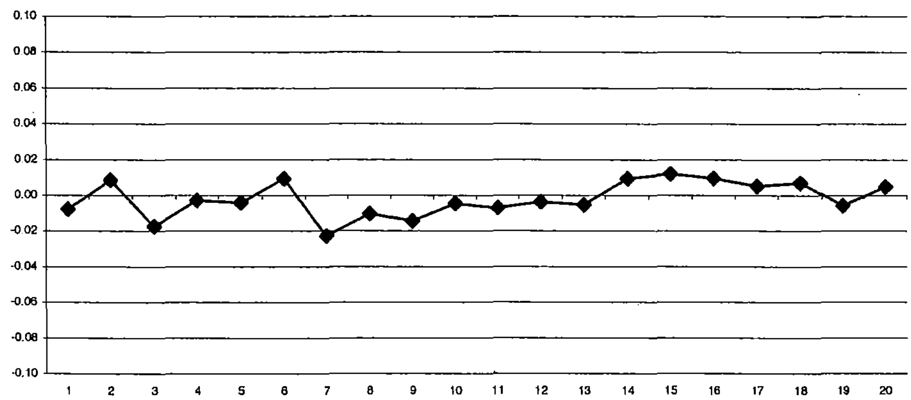
(c) Other asset price effects channel



(d) Credit-investment channel



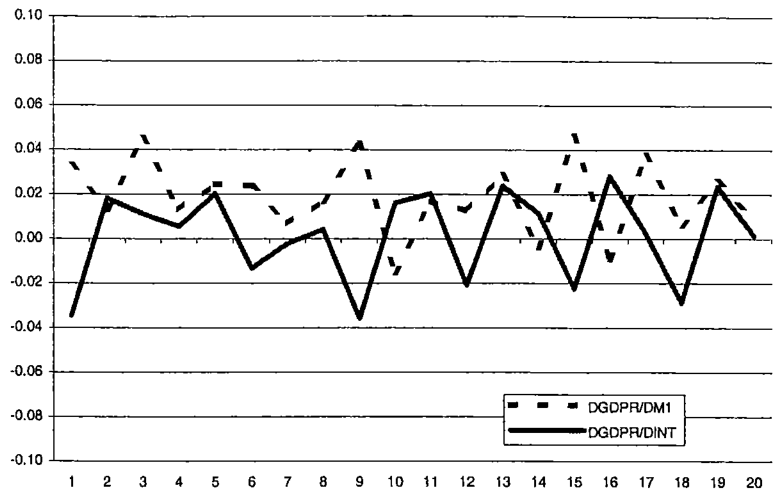
(e) Credit-consumption channel



To see how output reacts to money supply shock and to interest rate shock in a more realistic setting, a larger VAR incorporating all the variables is estimated. Impulse responses of output due to money supply and interest rate shocks are shown in Fig 7.3.7 below. This is the counterpart of Fig 7.2.8 that shows the impulse responses for New Zealand.

The responses in Fig 7.3.7 are indeed very interesting. First, it is quite obvious that the response of output to interest rate shock is now larger than the corresponding responses in the individual transmission models shown in Fig 6.5.5—in fact, it is almost the same (in absolute value) as the response due to the money supply shock. This would seem to suggest that the presence of the money supply enhances the influence of the interest rate on output,

Fig 7.3.7 Output response to money supply and interest rate shocks
The encompassing model



a result that would collaborate well with Leeper and Roush (2003) assertion that *"the money stock and the interest rate jointly transmit monetary policy"*, and also with Meltzer (1999) contention that *"both transmission processes* (referring to the interest rate and money balances*) are at work, so it is more difficult to reliably separate their relative importance"*.

The effect of the interest rate shock however on output seems to occur very late, i.e. the peak effect occurs in the 9th quarter (over two years later) whereas output response to the money supply shock starts from in 3rd quarter. Again this shows the dominant impact of money supply on output rather than the interest rate, at least in the initial periods after the exogenous shock.

Another very interesting pattern observed in Fig 7.3.7 above is the simultaneous peaking of the two output responses in the 9th quarter and the 15th quarter[53]. The magnitudes of the responses are also very similar, though of opposite signs. This implies that in the long run both the monetary aggregate and the interest rate changes have equal lag effects on output, both in terms of magnitude and timing. This is somewhat different to the evidence from

[53] According to Lown and Morgan (2002) the output response to the funds rate shock *starts off with no response for three quarters, peak response at six-to-eight quarters, persisting effects for ten quarters.*

New Zealand that shows a fairly dominating influence of interest rate over money supply in the long run.

Summary

In summary we see that output response to interest rate shock in Australia is generally lower than the corresponding response in New Zealand. This lower magnitude in Australia is supported by other empirical studies that find small or negligible impact of monetary policy innovations[54] on output (see, for example, Brischetto and Voss, 1999; Gruen te al., 1999; Orden and Fisher, 1993, among others). However as noted in the encompassing model, the effect of interest rate on output in Australia seems to be enhanced by the presence of monetary aggregate—in fact, the lag-effects of both are basically the same. This provides direct empirical support to the claim that "money matters"[55]. With reference to the different transmission channels there are important specific differences that are worth noting. For instance, in New Zealand the significance of the interest rate shock on output is more evident in the exchange rate channel whereas the money supply shock largest impact comes from the traditional interest rate channel. In the case of Australia, the money supply shock maximum impact on output is noted particularly in the interest rate and the exchange rate channels. The interest rate shock effect, as noted above, is quite negligible. To extend the comparison to other countries, the significance of fixed investment as a determinant of output growth in New Zealand would be consistent with the evidence from Europe while the Australian situation would be more similar to the US case[56].

Output variance decomposition

Here we are interested in the proportions of output variance explained by the different shocks within each transmission model. These proportions are shown in Table 7.3.6 below—this is the counterpart of Table 7.2.13 that shows New Zealand decompositions.

Out of the transmission models shown in Table 7.3.6 the interest rate channel explanatory power (other than output itself) of 57 per cent is the highest, but this is slightly less than the

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[54] This generally refers to short-term interest rate innovation.

[55] Other studies that find the importance of money supply in the transmission process include Beckitti and Morris (1992), Favara and Giordani (2002), Leeper and Roush (2003), Meltzer (1999), Meyer (2001), Morsink and Bayoumi (2001), Papadopoulos and Papanikos (2001), among others.

[56] The comparison of Europe and the US transmission mechanisms can be cited in Angeloni et al. (2002).

Table 7.3.6 Aust: Output (DGDPR) variance decompositions (%)

	Interest rate channel				*Exchange rate channel*				
Lags	DM1	DINT	DKF	DGDPR	DM1	DINT	DEXCH	DEXP	DGDPR
1	18.67	3.96	16.81	60.56	10.14	0.32	1.76	2.34	85.44
2	20.58	3.62	13.94	61.85	13.74	0.84	1.64	2.15	81.63
3	29.75	3.59	14.40	52.27	25.13	2.15	1.50	2.54	68.68
4	30.01	3.58	14.35	52.06	24.85	2.59	1.83	3.22	67.50
5	32.41	4.03	13.81	49.75	22.42	2.55	4.02	9.97	61.04
10	35.64	3.96	15.06	45.34	23.47	2.56	7.22	13.28	53.48
20	37.78	3.84	14.99	43.39	22.89	2.58	8.77	14.91	50.85
30	38.20	3.80	15.18	42.82	22.85	2.58	9.05	14.89	50.63
40	38.34	3.78	15.35	42.54	22.85	2.58	9.06	14.89	50.62

	Other asset price channel				*Credit investment channel*			
Lags	DM1	DPE	DPCE	DGDPR	DM1	DCRED	DKF	DGDPR
1	1.92	1.74	0.00	96.33	15.66	0.70	8.90	74.74
2	2.63	1.59	1.63	94.15	15.64	3.43	8.46	72.46
3	8.05	3.72	9.64	78.59	20.49	8.54	8.99	61.99
4	7.87	3.65	10.65	77.82	19.58	12.57	8.77	59.07
5	9.92	3.92	12.03	74.14	20.97	12.24	8.41	58.37
10	15.53	4.54	13.31	66.63	23.09	12.99	8.90	55.02
20	20.28	5.04	14.03	60.66	24.48	13.87	9.53	52.12
30	22.84	5.32	13.64	58.19	25.10	14.38	9.66	50.86
40	23.90	5.45	13.52	57.12	25.45	14.72	9.80	50.03

	Credit consumption channel			
Lags	DM1	DCRED	DPCE	DGDPR
1	1.76	3.56	0.38	94.29
2	1.69	3.59	1.47	93.25
3	4.63	4.61	9.16	81.60
4	4.35	5.57	11.97	78.12
5	6.60	5.20	13.50	74.69
10	13.00	5.47	17.05	64.49
20	17.22	5.98	18.03	58.77
30	19.95	6.39	17.29	56.37
40	21.41	6.57	16.91	55.10

corresponding figure for New Zealand of 62 per cent. But whereas in New Zealand the most influential variable is fixed investment, explaining 42 per cent of the output variance, in Australia it is money supply shock with explanatory power of 38 per cent. In fact, money supply explanatory power in all the five transmission channels in Australia is well over 20 per cent, i.e. quite significant compared to the explanatory power of other variables. The interest rate shock, on the other hand, explains less than 4 per cent of output variance both in the interest rate and the exchange rate channel[57]. In New Zealand the money supply explanatory power in the different transmission channels, apart from the interest rate channel, is less than 10 per cent. This would suggest that money supply in New Zealand does not have the same influence over output and the other variables as in Australia.

Granger-causality analysis

The Granger or block causality test results for Australia are shown in Table 7.3.7 and its counterpart showing New Zealand test results is Table 7.2.14.

Table 7.3.7 Granger-causality test results
*dependent variable: output (*DGDPR*)*

Interest rate channel				***Exchange rate channel***			
Exclude	Chi-sq	df	Prob.	Exclude	Chi-sq	df	Prob.
DM1	4.471	4	0.346	DM1	7.633	5	0.178
DINT	1.576	4	0.813	DINT	2.816	5	0.728
DKF	4.303	4	0.367	DEXCH	6.875	5	0.230
				DEXP	5.806	5	0.326
All	13.323	12	0.346	*All*	20.499	20	0.427
Other asset price channel				***Credit-investment channel***			
Exclude	Chi-sq	df	Prob.	Exclude	Chi-sq	df	Prob.
DM1	6.774	4	0.148	DM1	2.947	5	0.708
DPE	1.286	4	0.864	DCRED	4.856	5	0.434
DPCE	7.553	4	0.109	DKF	6.210	5	0.286
All	18.659	12	0.097	*All*	17.904	15	0.268
Credit consumption channel							
Exclude	Chi-sq	df	Prob.				
DM1	7.419	4	0.115				
DCRED	3.517	4	0.475				
DPCE	7.223	4	0.125				
All	21.745	12	0.041				

From Table 7.3.7 the two most significant channels in terms of the Granger-causal effect on output are the credit-consumption and the 'other asset price effects' channels. The former is

[57] For comparison, Boivin and Giannoni (2002) study using US data finds that 20 per cent of output variance is attributable to monetary policy shocks in the pre-1980 sample, but in the post-1984 sample, the proportion has fallen to just 3 per cent. This is quite interesting because the data for Australia starts from mid 1980s as well and so it would seem output variance in both countries may have gone down since the 1980s. This low figure have prompted some researchers to conclude that monetary policy does not matter much. In New Zealand the corresponding figure is 5 per cent in the interest rate channel but 23 per cent in the exchange rate channel. Manchester (1989) study on the US data also reports very similar results as that of Australia, i.e. showing a decomposition of just 3.5 per cent. Ibrahim (2003) study also finds only 2.99 per cent for money and 1.26 per cent, as he puts it: *Both MYIP (money) and MYTB (interest rate) innovations explain only minimal fractions of variations in Malaysian real economic activity.*

significant at the 5 per cent significant level and the latter at the 10 per cent significant level. In New Zealand (see Table 7.2.14) these two channels, plus the exchange rate channel, also show quite significant Granger-causal effect but in particular the 'other asset price effects' channel which is significant even at the 1 per cent significant level. Both the credit-consumption and the exchange rate channel are significant at the 12 per cent level. In both countries therefore the most significant transmission channel in terms of overall Granger-causal effect on output is the 'other asset price effects' or (consumption wealth) channel.

In terms of individual variables, private consumption seems to have the most Granger-causal effect on output both in Australia and New Zealand. One possible explanation for this is that private consumption is generally a very large proportion of national income (or output) hence it would most likely to have a greater causal impact on output than exports or fixed investment. Furthermore, unlike exports or fixed investment, which are generally more volatile, private consumption is generally constant or fixed in relation to output hence we expect the causal relationship between the two to be more significant and robust. The other two significant variables are exports and equity price—but only in New Zealand.

7.4 Counterfactual analysis

Now that we have seen that there are indeed differences in the transmission features between the two countries the next important question is: *what if New Zealand monetary policy, in terms of interest rate movements, had followed that of Australia—in particular in the period of the radical reforms?*

The approach to the above question is to estimate a VEC model[58] comprising of money aggregate (M1), nominal interest rate (INT), price level (CPI) and real output (GDPR). These are generally the standard variables in VAR analysis[59] and although we could add more variables, the limited number of observations may give inflated standard errors. Besides, as we have seen in the previous analyses, the responses do not change much with the size of the VARs. The results of the cointegration test and the diagnostic tests are

[58] The use of the VEC model here is appropriate given the existence of cointegration relationship among the four variables.

[59] As Runkle (2002) noted, *"Explaining the relationships among money, interest rate, prices, and output is one of the most important challenges in macroeconomics"*.

shown in the appendix. The estimated model will be referred to as the 'original' model because to set up a counterfactual experiment we will reestimate the same VEC model but this time using interest rate series that has been modified. The modification involves replacing the interest rates in the period 1985:3 to 1990:4 by the set of interest rates that has been estimated based on the movements of the Australian interest rates in the same period. This model will be referred to as the 'modified' model. The output and price responses from the two models will be analysed and compared to see if indeed output would have been higher had interest rates in New Zealand followed that of Australia. Responses pertaining to New Zealand are shown in Fig 7.4.1 and Fig 7.4.2.

Looking at the responses in Fig 7.4.1 and Fig 7.4.2 we see that the responses are generally consistent with theory, i.e. we expect output and price to decline after monetary tightening. There is also a small positive response of price immediately after monetary policy shock that has come to be known as the 'price puzzle' in the literature—this shows our result is consistent with other empirical findings.

Focusing now on just output response, it is quite obvious that the modified model (Fig 7.4.2) shows a larger output response compared to the 'original' model (Fig 7.4.1) response. In fact, output response in the 'original' model seems to go to zero in the long run whereas output in the 'modified' model definitely shows a long run value of around 6 per cent. Interestingly, price response seems not to change much around a value of .2 per cent in both figures—this could be considered as an indication that the parameters of the model did not change much after modifying the interest rate values[60]. This implies therefore that had New Zealand adopted the same kind of interest rate movements as the Australian interest rate movements, especially during the period 1985:3 to 1990:3, then output in New Zealand would have been much higher than actually reported.

Now to get a rough idea of how much output New Zealand would have got had it followed Australian monetary policy, we note from Fig 7.4.2 that the long run value of output is close to 6 per cent. And from Fig 7.4.1, the corresponding value is 1 per cent, so the difference therefore is about 5 per cent. If one standard deviation of real GDP (in level) is \$2,696 million, then 5 per cent represents \$134 million. Thus output would have been

[60] This could be considered as providing some evidence that the model is not subject to the Lucas critique.

higher by this much had New Zealand adopted the same monetary policy stance as Australia in the period indicated.

Fig 7.4.1 NZ : Output and price responses
(of the original model)

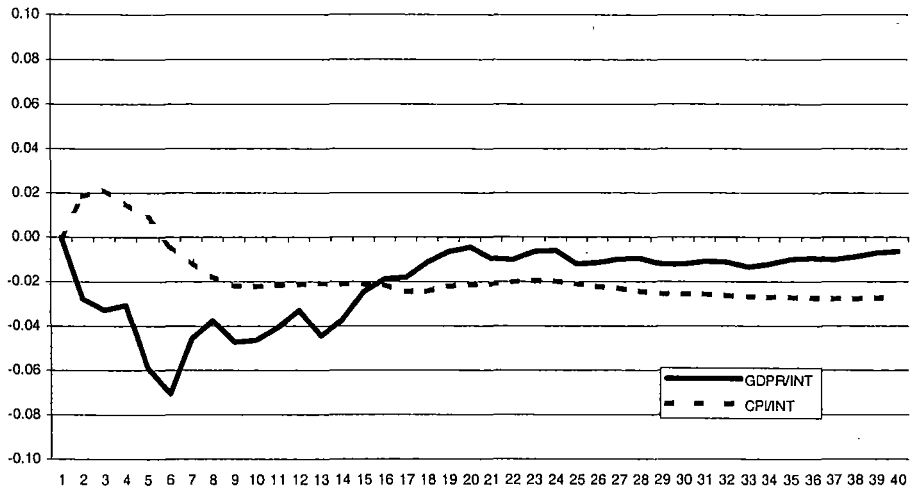
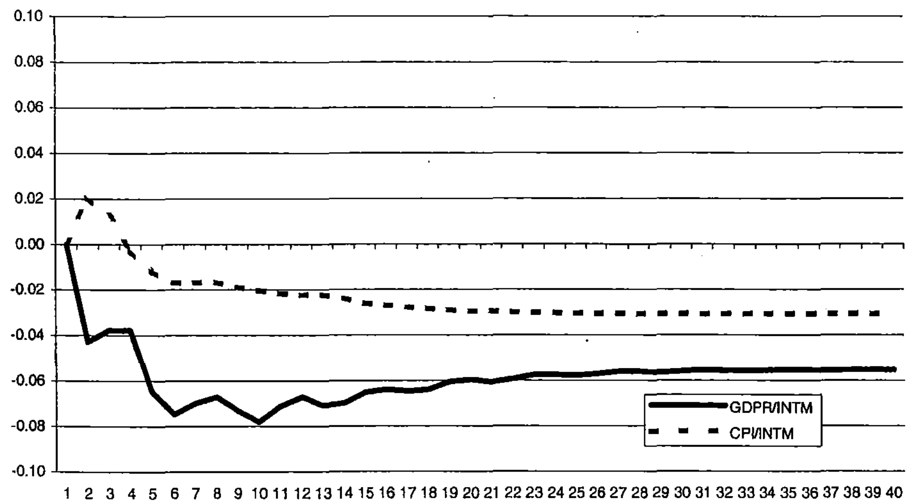


Fig 7.4.2 NZ : Output and price responses
(of the modified model)



To conduct a robustness test on the result we estimate a similar VEC model for Australia. The 'modified' interest rates are calculated as for New Zealand but now we are reversing the roles, i.e. we use New Zealand interest rate movements to modify the Australian interest rates for the same period indicated. The idea here is that by doing this we expect Australian output to decline relative to its 'original' level—at least it should not increase. The responses are shown in Fig 7.4.3 and Fig 7.4.4.

From Fig 7.4.4 we see Australian output does not decline as we hypothesized but at the same time, it does not increase as in the New Zealand case. So the evidence here seems to be in support of the hypothesis that monetary policy via the interest rate movements in New Zealand contributed to the decline in output observed since 1984.

Fig 7.4.3 NZ: Output responses

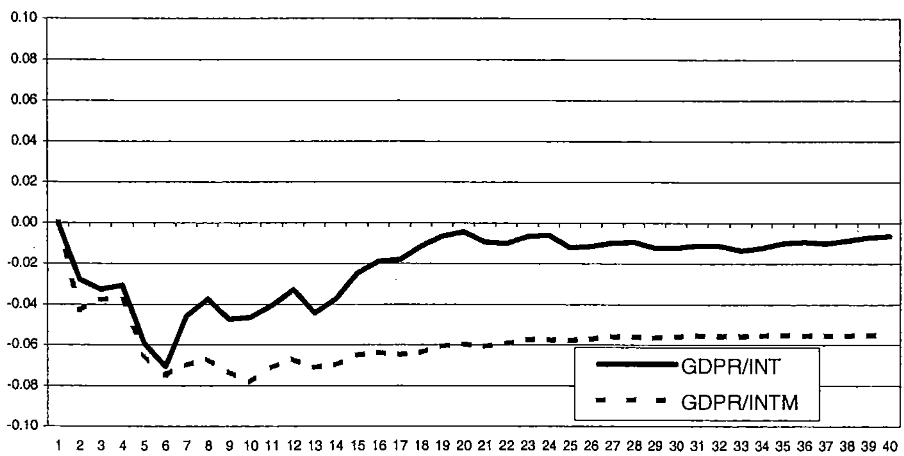
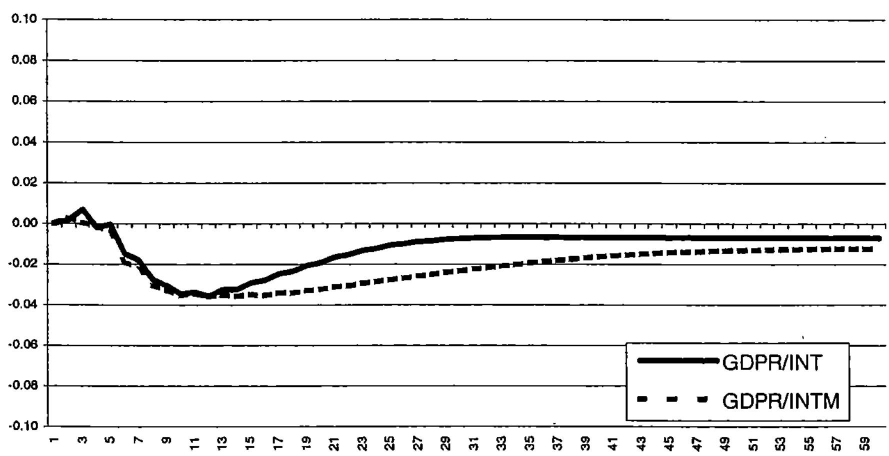


Fig 7.4.4 Aust: Output responses



7.5 Summary

On the basis of the 'liquidity' puzzle observed in both countries, with Australia showing more pronounced effect, we surmised that monetary policy makers in Australia tend to react 'faster' to inflationary pressure but in a more 'moderate' and sustained fashion, whereas policy makers in New Zealand tend to react a 'little bit slower' but their response is stronger and short-lived. Another interesting difference is the relatively high dependency of fixed investment on foreign funding sources in New Zealand whereas in Australia fixed capital formation depends to a large extent on domestic borrowings. And while exchange rate in New Zealand responds more to interest rate shock than in Australia, exports in Australia reacts immediately and more profoundly to exchange rate changes. This would suggest that Australia could absorb adverse shocks on exports better than New Zealand in the sense that when exchange rate appreciates, Australia would straightaway cut down its exports[61] but New Zealand would tend to carry on for the next two quarters before cutting down its export[62]. It is very apparent also, especially from the analysis on Australia data, that money supply has very significant impact on output. In New Zealand, money supply does have significant impact in the short run but in the long run it seems to give way to interest rate effect. And as to the question posed at the beginning of this section of whether monetary transmission (or monetary policy for that matter) can explain the divergence of output path of the two countries since the 1980s, the answer seems to be 'yes'. That is, the monetary tightening in New Zealand around the period 1985-1990 seems to be the cause of output dismal growth, at least the analysis shows that had New Zealand followed the interest rate movements of Australia then its output would have been higher. Despite this finding it is important to keep in mind that the analysis is fairly crude in the sense that it did not consider changes that would have had occurred to other variables should there be in fact changes to the interest rate in the period indicated, nevertheless, the result is interesting.

[61] There may be different ways or channels in which exports may be re-directed but according to Roos (2000), in Australia '*higher domestic activity serves to reduce exports*'.

[62] Another possible way of 'cushioning' the effect of high exchange rate on exports is to undertake currency hedging or using fixed price contracts.

Chapter 8

POLICY IMPLICATIONS AND CONCLUSIONS

8.1 Introduction

This last chapter discusses the policy implications of the results, the limitations of the study and offers some suggestions for future research. Obviously the empirical analysis has covered a fairly wide ground and while some results may have policy implications, others are likely to be more academic. In view of this, the following discussions will focus only on those results that seem to have important policy implications. Note that this chapter is not meant to summarise the results given that this has been done at the end of each major analysis in Chapters 6 and 7.

Before the policy implications are discussed, it may be useful to give a brief review of the main thrust of the study, re-emphasising where necessary the important considerations and the general underlying philosophy. Hopefully this should give more perspective to the analysis and to the study as a whole.

8.2 Brief review of the methodological approach

We started off by empirically testing the classical monetary neutrality and other related hypotheses, then moved on to examine and evaluate the different monetary transmission mechanisms and finally, we extended our analysis to Australia to see if there are significant and important differences in the monetary transmission mechanisms between the two countries. The two fundamental questions we wish to explore are: Does money affect real output? And, ii) How does the monetary impulse gets transmitted to real output? As discussed in the introduction and in the theory chapters this is a long standing issue that has intrigued economists since David Hume in the 18th Century first conceived the notion of the Quantity Theory in his essays of *Interest* and *Money*. But whereas in the past the focus was more on developing theoretical explanations of the money-output relationship, in recent years the interest is more on monetary policy and its transmission process to output or (inflation).

In reviewing the methodology adopted in this study it is worthwhile to stress the overriding philosophy which is to 'let the data speak'. In practical terms, this involves using unadjusted data and the vector autoregression framework. This might be labelled as 'measurement without theory' but like Bernanke and his colleagues who take the VAR evidence seriously[1], this study considers the results of the VAR analysis as representing important and useful relationships between the variables and consequently the entire analysis is based on the numerical values of the impulse response functions, the variance decompositions, and the Granger-Causality test results. While these numbers represent or reflect past events, they do also provide useful indicators of future events provided there are no major regime or structural changes in the subsequent periods.

In the analysis the emphasis is placed on the bivariate relationships and the sequential ordering as depicted in each theoretical monetary transmission model. This is unlike most VAR studies that tend to focus only on the response of output or inflation following an interest rate or money supply shock without actually tracing out the intermediate paths[2]. Obviously this 'direct' approach would miss out important and useful dynamics within the transmission models and in fact this drawback led to the introduction of the 'serial' transmission and 'parallel' transmission mode in this study. That is, the introduction of these transmission concepts is an attempt to systematically measure the responses, the decompositions and the Granger-causal effects, within and across the different monetary transmission mechanisms in accordance with the proposed theoretical models.

In order to simplify the analysis and the discussions, the structural shocks are given very straightforward names. For example, instead of using the terms such as technological shocks, fiscal shock, mark-up shocks, etc., (as done by Siregar, 2001; Siregar and Siregar, 2000; among others) the terms used here for the shocks simply come from the equation from which the shock originates. For example, real output shock comes from the output equation—likewise, money supply shock comes from the money supply equation, and so forth.

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[1] See Bernanke et al. (1997).
[2] This kind of approach is referred to in this study as the 'direct transmission' approach.

Because all the variables are in first-difference[3] the analysis and the discussions refer only to the names of the variables without specifying first-differences. Also it is important to note that because of the inherent inflated standard errors in a VAR framework, the emphasis in this study is more on the point estimates. In view of this, the word 'significant' may have been used in some instances more on a 'relative' basis than an absolute or statistical sense.

8.3 Policy implications

In order to present a coherent statement of the policy implications of the results, the following discussions are grouped under each major analysis section as in Chapters 6 and 7. This should clearly show where the results come from for ease of referencing and cross checking purposes.

Neutrality and superneutrality tests

Although the bivariate models used in the neutrality and superneutrality tests are not strictly monetary transmission channels, the bivariate relationships obtained from these tests do provide useful insight of how money supply, interest rate, inflation, output, etc., respond to each other. In fact, some of these bivariate relationships constitute the elements of the broader transmission channels like the interest rate channel, the exchange rate channel, etc. Furthermore, some of the bivariate relationships by themselves have important policy implications—i.e. even without referring to the particular transmission model they represent. This should become apparent in the following discussions.

With respect to the relationship between money supply and real output, the empirical evidence is in favour of the monetary long run neutrality proposition, however there is persistence in the output response that other researchers have noted as well. Furthermore, the impulse response analysis indicates a peak response of output of 4-5 per cent to money supply shock in the 4^{th} quarter. To put this figure in perspective, we note that output response to its own shock is around 8 per cent in the 5^{th} quarter hence the effect of money supply shock is fairly substantial if we go by the general rule that variation in each variable is explained mostly by its own shock (see, for instance, Kuszczak and Murray (1986, p.

[3] The exception being the VEC model which uses the variables in level.

87)). The policy implication of this evidence therefore is that monetary policy makers should pay heed to the movements of money supply, i.e. not to totally ignore it as reflected in recent monetary models of several central banks and that of the New Keynesians. That is, the evidence clearly shows that 'money matters'.

Another useful observation is that of the tendency of money supply (M1) to follow output movements following an output shock. However in the long run this reverts back to its equilibrium level. This suggests that an increase in output may induce inflationary pressure because of the increase in money supply but the effect would be temporary. So if there is a tightening of monetary policy to counter the inflationary pressure caused by an aggregate supply shock, then this tightening should be temporary because the effect will diminish over time, i.e. an extended tightening policy may adversely affect real output and other important economic variables.

When money M3 is used in place of M1 an interesting result is that a permanent output shock raises the level of M3 permanently—in contrast to the zero long run response of M1. Another interesting observation is that the money (M1) shock has higher impact on real output compared to the impact of M3 shock. These evidences clearly suggest that M1 is more exogenous and more influential than M3 hence if monetary policy is to be conducted through monetary aggregate, then M1 should be a more appropriate aggregate to use.

In terms of the relationship between money supply and price level, the analysis shows that price responds equiproportionally to money supply increases. This provides empirical support to the Monetarist's contention that "inflation is a monetary phenomenon". Furthermore, it is important to note the relatively strong and highly persistent price increase following a monetary shock (see Fig 6.3.17). For almost eight quarters (i.e. two years) the price level remains positive after the initial monetary shock. This clearly highlights the need for policy makers to make sure there is no 'dramatic' increase in money supply, even a temporary one, for this will cause a significant and persistent rise in price level.

In comparing the responses of price and output to money supply shock it is seen that inflation response is more extended and more pronounced so it makes sense for policy makers to focus more on price stability than on real output.

Although Fisher's relationship is one of the important classical relationships investigated, the more practical relationship, at least from the monetary policy standpoint, is that of inflation rate response to the interest rate shock, i.e. the reverse of Fisher's relationship. This is because interest rate is often considered as the monetary policy tool, i.e. controllable by the central bank whereas the inflation rate is more of a target variable, i.e. an endogenous variable. And from the bivariate analysis the inflation rate response following the interest rate shock shows a temporary rise in the 3rd quarter followed by a negative response. The policy implication of this is that following monetary tightening there may be a temporary rise in price[4] in the first few quarters but in the long run, price will decline.

On the superneutrality test the evidence shows a negative output bias following a permanent change in the level of the inflation rate. That is, the evidence does not support the superneutrality hypothesis. In the context of policy, this evidence lends support to the idea that high inflation is detrimental to output growth, i.e. the policy of price stabilization is a sound policy.

The next section will discuss the policy implications of the results of the evaluation of the monetary transmissions using New Zealand data.

Evaluation of the monetary transmission mechanisms

In the analysis we looked at basically three transmission approaches: the serial bivariate transmission approach; the parallel transmission approach; and the 'direct' transmission approach. In the first two approaches the focus was on tracing out the serial flow of the monetary impulse from the source (either the money supply or the interest rate) through the 'intermediate' variables and finally to real output. This may be considered as a serial flow analysis but in the serial bivariate approach a series of bivariate VAR models were actually estimated and subsequently ordered according to the orderings in the theoretical transmission models. In the parallel transmission approach the same serial analysis was undertaken but the bivariate relationships were 'extracted' from the larger VAR

[4] This is known in the literature as the 'price puzzle'.

transmission models. These larger models in fact provided the basis for the 'direct' transmission approach as well.

In studying the empirical relationship between money supply and interest rate, the conclusion is that the interest rate leads money supply, i.e. the interest rate is more exogenous than money supply. The implication of this finding is that the theoretical transmission models, like the traditional interest rate channel, or the exchange rate channel, should have the interest rate as the starting point of the transmission channel rather than the money supply. In terms of policy setting, the interest rate should be a more appropriate instrument or tool to manipulate than the monetary aggregate given that it is more exogenous. In fact, in the 'direct' transmission analysis, the effect of the interest rate shock on output is more sustained than that of the money supply shock.

Another interesting bivariate relationship is between the interest rate and the exchange rate. As Table 7.2.8 shows, the impact of the interest rate shock on the exchange rate is immediate and quite significant. In contrast the impact of interest rate shock on fixed investment is relatively weak. This would suggest that if the country is faced with the choice of either restraining fixed investment spending (like housing construction) and promoting exports or encouraging fixed investment and depressing exports, then policy makers should consider exports promotion as a more reasonable choice given that fixed investment is not very responsive to interest rate changes while exchange rate does respond strongly to interest rate movements. Furthermore, the Granger-causality test shows that the exchange rate affects exports significantly. The only problem here, however, is that the export response to the exchange rate change takes some time so if the interest rate is lowered the short run cost would be an outflow of capital and possibly some inflationary pressure.

The response analysis also found that out of the demand aggregates studied, fixed investment shock affects output the most. This finding is also confirmed from the variance decomposition analysis that shows fixed investment shock explaining about 40 per cent of the variation in output compared to 31 per cent due to exports shock and just 12 per cent due to private consumption shock. In view of these evidences, the government should encourage businesses to spend more on fixed investment as this is a major driving force of output growth. One traditional method of encouraging this investment spending is to lower the interest rates but given that fixed investment in New Zealand does not respond strongly to interest rate changes, the government may opt for higher interest rate as this will encourage foreign investors to invest in or bring more capital to New Zealand. The only drawback here is the adverse impact this might have on the export sector. One way to mitigate this is to have fixed price contract or exchange rate hedging, and as noted in the analysis, New Zealand exporters are doing both. So one attractive policy setting is to raise the interest rate to a level that is attractive enough for external investors and at the same time to encourage exporters to enter into long term fixed price contracts or currency hedging. Another benefit from this policy prescription, besides capital inflows, is the restraint on inflation rate. The important thing is to keep a close watch on the contracts and the hedging periods so when they are about to run out, then the government should consider lowering the interest rate.

Looking at the transmission channels as a whole, the interest rate channel and the exchange rate channel have relatively high response summary measures when the source of shock is the interest rate. If the source of shock is the money supply, then the credit channels become more prominent. This implies that if government should conduct monetary policy through the interest rate, then the more relevant channels to consider are the traditional interest rate and the exchange rate channels. On the other hand if the government uses the monetary aggregate as its policy instrument, then the credit channels are likely to propagate the monetary impulse more effectively, in particular the credit-consumption channel. The importance of the credit channels also means that the government should give due considerations to the role and importance of the banking sector in the management of the economy as argued by Claus and Grimes (2003), Dalziel (2001), Guttmann (1994), among others.

In terms of the lag-periods, the exchange rate channel has the longest lag-period (almost three years) while the interest rate channel and the credit-consumption have relatively shorter lag-periods (less than two years). The delayed impact of the exchange rate shock on exports (almost two years) is the main reason why the exchange rate channel has such a long lag-period. The policy implication of this is that monetary policy tightening would be felt more quickly on private consumption and fixed investment rather than on exports. This implies that while the monetary policy can be used in the short urn to influence consumption and investment, in the long run exports could be adversely affected.

Comparative analysis between Australian and New Zealand

In the bivariate relationships, fixed investment response to the interest rate shock is 17 per cent for Australia and less than 10 per cent for New Zealand. This clearly shows the importance of bank loans to investment in Australia and therefore policy makers in Australia should be wary of the adverse impact of monetary tightening on investment. The lower figure for New Zealand, on the other hand, would mean that given the choice of low investment against higher exchange rate, policy makers in New Zealand should consider the benefits or the consequences of currency changes rather than the impact of interest rate on fixed investments.

With respect to the impact of the exchange rate shock on exports, in Australia this is more immediate than in New Zealand and slightly higher in magnitude. This implies that exports from Australia would immediately decline when the exchange rate becomes unfavourable. If the 'intended' exports could be redirected for domestic consumption then the income of the exporters would not be adversely affected but the question of how long the domestic economy could shield the exporters needs to be addressed. In the case of New Zealand, where export is critical to the economy, monitoring the exchange rate carefully is very important. The delayed and lower response of exports to exchange rate appreciation noted in the analysis means that exporters have entered into some kind of fixed price contracts or foreign exchange hedging but if the exchange rate keeps rising or persistently remains at a high level, this could mean huge hardship for exporters eventually. This clearly shows the vulnerability of New Zealand exporters to exchange rate fluctuations so it is only logical for policy-makers in New Zealand to take prudent steps, at least those that are within their means, in order not to inflate the exchange rate and exacerbate its adverse effects. As commonly known, raising the interest rate is one way of increasing the exchange rate therefore policy makers need to consider carefully the cost of lower exports against high inflation. One possible solution that has been discussed above is simply to encourage exporters to enter into long term fixed price contracts for their exports or to undertake foreign exchange rate hedging.

One very interesting difference in the monetary transmission process between the two countries is the dominance of the money supply effect on output (and other variables) in Australia whereas in New Zealand the interest rate seems to have more lasting effect on output. So in terms of which variable is more effective as a monetary policy tool, the evidence suggests that in Australia it would be the money supply but in New Zealand it would be the interest rate. However it is important to note that both variables do have impact on output and therefore it is wise to monitor constantly the movements of both variables. This would be consistent with Meltzer (1999) concluding sentence: *Whether making a discretionary judgement or following a rule, history suggests that the bank will avoid large, costly errors if it does not ignore the role of changes in nominal money and in real balances when making its decisions.* Meyer (2001) also suggested the importance of money supply in his concluding paragraph, "..... *I believe monitoring money growth has value, even for central banks that follow a disciplined strategy of adjusting their policy rate to ongoing economic developments".*

In comparing the exchange rate channel summary responses across the two countries New Zealand has a higher figure of 0.25 per cent (see Table 7.2.10) compared to 0.06 per cent for Australia (see Table 7.3.3). In view of this, monetary policy makers in New Zealand should try to focus more on the impact of their monetary policies on the exchange rate channel while policy makers in Australia should focus on the 'other asset price effects' channel.

Looking at the total lag periods of the different transmission channels, in general the lag periods in Australia are longer than the lag periods in New Zealand—except for the exchange rate channel. This would suggest that the effects of monetary policy changes on real output in Australia take time to be felt therefore it would be advantageous for policy makers in Australia to take earlier actions than their counterparts in New Zealand. Note however that this refers to the intended effect on output only as the study focused exclusively on real output rather than on inflation.

On the counterfactual experiment there is clear evidence that the monetary policy, via the interest rate, has a significant impact on output and indeed can cause stagnant growth if applied too stringently (see Fig 7.4.1 and Fig 7.4.2). The analysis shows that had New

Zealand followed a 'looser' monetary policy in the mid 1980s, like Australia, its output would have been much higher.

8.4 Limitations of the study

As with all studies, in particular the empirical ones, there are shortcomings or limitations and this study is no exception. The following are some of the limitations that could have important influence on the outcomes of the study.

The use of the Cholesky or recursive identification scheme may not represent the true structural model that we are interested in. In particular the structural shocks that suppose to represent, say the monetary policy action, or the supply side shock, may have not been properly identified[5].

With respect to the size of the models, the number of variables used here is generally small compared to other VAR studies[6]. In view of this there may be some concern for the 'omitted' variable bias effect. In fact in the analysis, there is evidence of an 'omitted' variable bias in some of the bivariate models. The implication of this is that some responses or decompositions may have been overstated or understated depending on the correlation coefficient magnitude and sign between the omitted variable and the explanatory variable.

Because of the time factor and data availability, and to some extent because of the thesis guidelines, not all monetary transmissions were covered. Furthermore, some important variables or constructs commonly employed in other monetary transmission studies, such as the Tobin 'q' measure, the external finance premium, or the real interest rate, have not been used here. This would imply that some of the transmission models employed in this study may have not been properly formulated—at least not 'sophisticatedly' formulated.

In the analysis of the monetary transmission mechanisms, especially in the parallel transmission approach where the larger VARs are used, the analytical framework used is

[5] As noted by Fackler and Rogers (1993), *"However, the 'fundamental' or structural shocks to the economic system under investigation are unlikely to be represented by such decomposition of the VAR residuals"*. The authors are referring to the Cholesky decomposition.

[6] For instance, Buckle et al. (2003) study uses 13 variables while both Siregar (2001) and Wongsaart (1997) studies use seven or more variables.

the standard VAR in first-difference. This is done in order to be consistent as well as to facilitate the analysis and the comparison. However if there were any cointegration relationship between the variables, then this would mean some of the models might have been misspecified.

The size of the sample, in particular the sample used in the evaluation of the different monetary transmission of just over sixty is not long enough and this may give some erratic or irregular responses but more importantly the standard errors will be quite large. The implication of this is that the empirical confidence intervals for our estimates are rather wide, so any reference to the confidence interval may not very meaningful. This is one reason why in this study the emphasis is more on the point estimates rather than on the confidence intervals, at least the point estimates are still unbiased and provide objective and useful measures for comparison.

In the counterfactual analysis we did not consider the Lucas Critique however as with most policy simulation and analysis, there is the prospect of parameter instability, in particular if the economy has undergone structural changes or the data is quite extended. While there may be criticisms against the Lucas Critique (see, for example, Marcellino and Salmon (1999)), the idea of checking whether the parameters have changed after changing the interest rates is reasonable, however this has not been done in this study. One reason for this is that to assess the Lucas Critique one needs fairly complicated models incorporating expectations and alternate policy rules on the economy[7]. Besides, there are VAR and non-VAR macroeconomic models without explicit expectations that appear to be *fairly stable empirically* (Rudebusch, 2003) so the Lucas Critique is not that robust or 'formidable' as it was once considered. Another empirical study that finds no support for the Lucas Critique is that of Perez (2002).

Another limitation of the analysis, but this is applicable to the VAR framework in general, is the fact that it is not possible to isolate the impact or the effect of a single shock on another variable[8]. That is, the response of output, or any variable for that matter, is the

[7] An empirical assessment of the Lucas Critique is given in Rudebusch (2003).
[8] The closest one could get to this ideal situation is to use a bivariate model where only two variables are able to influence each other. Another common approach is to 'shut off' the effects of other variables by

resultant of several disturbances, including its own lagged values. This would mean that when we talk of the impact of a monetary policy shock on output or inflation, we are actually referring to a situation where the 'initial' shock or disturbance comes from the monetary policy instrument. That is, the initial chain reaction comes from the policy instrument but what happens later in the system is always a resultant of several factors.

8.5 Suggestions for future research

The following will suggest some areas that could be of interest to future research. Obviously most of the suggestions will be related to the limitations discussed above while some are just extensions to the present study.

This study has focussed exclusively on the effects of monetary impulse on real output. Another useful approach would be to consider inflation as the final target of the transmission process. With many countries around the world focusing on price stability, including New Zealand and Australia, this approach would be very relevant and practical.

In terms of the identification scheme one may try the structural decomposition scheme where the contemporaneous restrictions are not strictly recursive, i.e. it is up to the user how he or she views the transmission process or the economic structure and accordingly put in the required restrictions (as done by Fackler and Rogers, 1993).

It would be useful also to enlarge the models in order to incorporate more relevant variables. This may include 'external' variables such as the US of Japanese output or interest rate, i.e. countries that are known to have substantial interactions with New Zealand or Australia. Furthermore, it would be interesting to derive and use empirical proxies for some of the concepts used in the various transmission channels, such as 'wealth', 'moral hazard', 'adverse selection', etc. This should be more representative of the transmission process and therefore more useful for policy purposes. One major problem here is the subjectivity and ambiguity of such terms as wealth, moral hazards, and so forth. The availability of data would be another major obstacle.

restricting their coefficients to zero, as is done in Ludvigson et al. (2002).

In view of the difference in the response of fixed investment to the interest rate shock in the two countries, and given the importance of fixed investment to economic growth, it would be interesting and useful to extend the analysis using the components of fixed investment[9] or interest rates. These components may include housing, plants and machinery, transport equipment or short-term interest rate, real interest rates, and so forth. In splitting fixed investment or the interest rate this way, more specific information could be obtained which the policy makers could use instead of the very broad category like 'fixed investment'.

There are only two countries involved in the comparison analysis in this study, yet very interesting differences are noted in the monetary transmission processes so to make an even more universal and useful comparison more countries should be incorporated in the analysis—as is done in Europe (see, for instance, Angeloni et al., 2002; Britton and Whitley, 1997; Cecchetti, 1999; among others). This should include countries that are known or suspected to have significant interactions with New Zealand or Australia. In doing this one may get a more comprehensive understanding of how the monetary transmission actually works both within the countries and across the countries—and for small open economies like New Zealand and Australia, this is crucial.

Another interesting challenge is to carry out more elaborate studies on the serial and parallel transmission concepts introduced in this study with a view of developing forecasts based on the results. Tracing out the serial and parallel impacts of the monetary policy, say starting from the time the Governor of the Reserve Bank decided to increase the official cash rate right through to the time the effects are seen or felt on output (or inflation) would surely help policy makers to understand where the delay comes from or where the transmission fails because of the very low response noted, and so forth. These types of information are possible to derive from the sort of bivariate relationships that have been extensively examined and discussed in this study. The information is crucial not only for forecasting purposes but also for making the public understand the uncertainties associated with the transmission mechanism. The alternative is simply to look at the direct transmission approach that focuses only on the response of output (or inflation) to the interest rate or the money supply shocks leaving aside the 'intermediate' steps as an

[9] As done in Bernanke and Gertler (1995), Mauskop (1990), among others.

economic 'black box'. Unfortunately most studies up to now have chosen to pursue the alternative.

8.6 Conclusions

The study has produced very interesting results and useful insights. Some results are consistent with existing theories and past empirical studies while others either show contradictory results or totally new insights. With respect to the main objective of this study which is to try to understand how money affects output through the so-called monetary transmission channels, the main finding is that the issue is complex and cannot be summarised into a single sentence or in a single paragraph. Essentially the results and the analysis show that monetary transmission is possible through many channels, each with its own unique pattern and lag-period. Furthermore, when the source of monetary shock is changed, say from money supply to interest rate, the responses, the decompositions and the Granger-causality test results all changed as well. This really stresses the need to be careful of what monetary policy instrument is being used or what monetary transmission mechanism is being investigated. For instance, in Australia the money supply effect on output is quite significant but in New Zealand the interest rate seems to be more influential. There is also evidence that both the interest rate and the money supply are important for the conduct of monetary policy. This evidence clearly shows that 'money matters'. The analysis also demonstrated that the credit channel is an important transmission channel in addition to the traditional interest rate and the exchange rate channels. Another useful conclusion is that the monetary transmission process is different from country to country, and possibly from period to period depending on the monetary policy regime and financial institutional set-up. So to wrap up the discussion we can say that although it is possible to 'peek' inside the co-called 'black box' using the VAR tools and the serial and parallel transmission approaches, it is still not possible to generalize the transmission process because there are so many possibilities—and none seems to stand out over the other. In practical terms, the formulation of monetary policies needs careful planning taking into account not only the direct impact of policy instrument changes on output (or inflation) but also the intermediate steps that characterise the different monetary transmission channels—they too have their own unique 'story' to tell.

REFERENCES

Ahn, B.C. (1994) "Monetary Policy and the Determination of the Interest Rate and Exchange Rate in a Small Open Economy with Increasing Capital Mobility" *The Federal Reserve Bank of St. Louis Working Paper,* 1994-024A.

Amisano, G. & Giannini, C. (1997) *"Topics in Structural VAR Econometrics"* Berlin: Springer.

Amstrong, R. (2004, 4 February). "Boom-bust cycle set to repeat" *THE PRESS, Christchurch.* p. B13.

Angeloni, I., Kashyap, A., Mojon, B. & Terlizzese, D. (2002) "Monetary Transmission in the Euro Area: Where Do We Stand?" *European Central Bank Working Paper,* 114.

Archer, D., Brookes, A. & Redell, M. (1999) "A Cash Rate System for Implementing Monetary Policy" Financial Markets Department, Reserve Bank of New Zealand, Retrieved 20 June 2002 from World Wide Web: http://www.rbnz.govt.nz/research/bulletin/1997_20/1999mar62_/ archerbrookesreddel.pdf

Arestis, P. & Sawyer, M. (2002) "Can Monetary Policy Affect The Real Economy?" *Washington University of St. Louis Working Paper,* 355.

Aron, J. & Muellbauer, J. (2002) "Interest Rate Effects on Output: Evidence from a GDP Forecasting Model for South Africa" *IMF Staff Papers*, 49.

Azali, M. & Mathews, K.G. P. (1999) "Money-income and Credit-income Relationships During the Pre- and Pos-Liberalization Periods: Evidence from Malaysia" *Applied Economics*, 31(10), 1161-1180.

Bean, C., Larsen, J., Nikolov, K. (2002) "Financial Frictions and the Monetary Transmission Mechanism: Theory, Evidence, and Policy Implications" *European Central Bank Working Paper Series,* 113.

Beckitti, S. & Morris, C. (1992) "Does Money Still Forecast Economic Activity?" *Federal Reserve Bank of Kansas City Economic Review*, 77(4), 65-72.

Begg, D.K.H., Dornbusch, R. & Fisher, S. (1991) *"Economics"* 3rd ed., Maidenhead: McGraw-Hill.

Bernanke, B.S. (1988) "Monetary Policy Transmission: Through Money or Credit?" *Federal Reserve Bank of Philadelphia Business Review*, Nov/Dec, 3-11.

Bernanke, B.S.& Blinder, A.S. (1992) "The Federal Funds Rate and the Channels of Monetary Transmission" *The American Economic Review,* 82(4), 901-21.

Bernanke, B.S. & Gertler, M. (1995) "Inside the Black Box: The Credit Channel of Monetary Policy Transmission" *Journal of Economic Perspectives,* 9(4), 27-48.

Bernanke, B.S., Gertler, M. & Watson, M. (1997) "Systematic Monetary Policy and the Effects of Oil Price Shocks" *Brookings Papers on Economic Activity*, 1, 91-142.

Berument, H. (2001) "Measuring Monetary Policy for a Small Open Economy: Turkey" Unpublished Paper, Department of Economics, Bilkent University, Ankara, Turkey. Retrieved 7th March 2003 from World Wide Web: http://www.econturk.org/Turkisheconomy/berument01.pdf

Blanchard, O.J. (1990) "Why Does Money Affect Output?" in B.M. Friedman & F.H. Hahn (eds) *Handbook of Monetary Economics*, Vol. 2, Amsterdam: North-Holland.

Blanchard, O.J. (1997) *"Macroeconomics"* New Jersey: Prentice-Hall.

Blundell-Wignall, A., Fahrer, J. & Heath, A. (1993) "Major Influences on the Australian Exchange Rate" *Paper for the Conference on The Exchange Rate, International Trade and the Balance of Payments, 12-13 July 1993*, Reserve Bank of Australia.

Boivin, J. & Giannoni, M. (2002) "Assessing the Changes in the Monetary Transmission Mechanism: A VAR Approach" *Federal Reserve Bank of New York Economic Policy Review,* May, 97-111.

Bondt, G.J. de (1999) "Credit Channels and Consumption in Europe" *Bank for International Settlements Working Paper,* 69, June.

Boschen, J.F. & Otrok, C.M. (1994) "Long-Run Neutrality and Superneutrality in an ARIMA Framework: Comment" *American Economic Review,* 84(5), 1470-73.

Bredin, D. & O'Reilly, G. (2001) "An Analysis of the Transmission Mechanism of Monetary Policy in Ireland" *Central Bank of Ireland Technical Paper* 01/RT/01.

Brischetto, A. & Voss, G. (1999) "A Structural Vector Autoregression Model of Monetary Policy in Australia" Research Discussion Paper 11, Economic Research Department, Reserve Bank of Australia.

Britton, E. & Whitley, J. (1997) "Comparing the monetary transmission mechanism in France, Germany and the United Kingdom: some issues and results" *Bank of England, Quarterly Bulletin,* 32(2), 152-162.

Brunner, K. & Meltzer, A.H (1988) "Money and Credit in the Monetary Transmission Process" *The American Economic Review*, 78(2), 446-51.

Brunner, K. & Meltzer, A.H (1990) "Money Supply" in B.M.Friedman & F.H.Hahn (eds) *Handbook of Monetary Economics*, Vol. 1, Amsterdam: North-Holland.

Buckle, R.A., Kim, K., Kirkham, H., McLellan, N. & Sharma, J. (2002) "A Structural VAR model of the New Zealand Business Cycle" *New Zealand Treasury Working Paper,* 02/26.

Buckle, R.A., Kim, K. & McLellan, N. (2003) "The Impact of Monetary Policy in New Zealand Business Cycles and Inflation Variability" *New Zealand Treasury Working Paper,* 03/09.

Bullard, J. (1999). "Testing Long-Run Neutrality Propositions: Lessons from the Recent Research" *Federal Reserve Bank of St.Louis Review,* Nov/Dec., 57-77.

Bullard, J. & Keating, J. (1995) "Superneutrality in Postwar Economies" *Federal Reserve Bank of St.Louis Working Paper,* 1994-011B.

Cagan, P. (1993) "Does Endogeneity of the Money Supply Disprove Monetary Effects on Economic Activity?" *Journal of Macroeconomics*, 15(3), 409-422.

Cecchitti, S.G. (1999) "Legal Structure, Financial Structure, and the Monetary Policy Transmission Mechanism" *Federal Reserve Bank of New York Economic Policy Review,* July, 9-28.

Chatelain, J.B., Generale, A., Hernando, I., Kalckreuth, U. & Vermeulen, P. (2002) "Firm Investment and Monetary Policy Transmission in the Euro Area" Unpublished Paper, European Central Bank, Retrieved 11th July 2003 from World Wide Web: http://econpapers.hhs.se/cpd/2002/14_vermeulen.pdf

Chatterjee, S. (2001) "Why Does Countercyclical Monetary Policy Matter?" *Federal Reserve Bank of Philadelphia Business Review,* 2, 7-14.

Cheung, Y. & Fujii, E. (1999) "A Note on the Power of Money-Output Causality Tests" Unpublished Paper, Department of Economics, University of California, Santa Cruz. Retrieved from World Wide Web: Http://econ.ucsc.edu/faculty/cheung/99080xfb.pdf

Chirinko, R.S. (1993) "Business Fixed Investment Spending: Modeling Strategies, Empirical Results, and Policy Implications" *Journal of Economic Literature,* XXXI, Dec, 1875-1911.

Christiano, L.J., Eichenbaum, M. & Evans, C.L. (1998) "Monetary Policy Shocks: What Have We Learned and to What End?" in J. Taylor and M. Woodford (eds) *Handbook of Monetary Economics* North-Holland.

Chrystal, K.A. & Mizen, P. (2002) "Empirical Evidence for Credit Effects in the Transmission Mechanism of the United Kingdom" in L. Mahadeva and P. Sinclair (eds) *Monetary Transmission in Diverse Economies*, Cambridge: Cambridge University Press.

Claus, I. & Grimes, A. (2003) "Asymmetric Information, Financial Intermediation and the Monetary Transmission Mechanism: A Critical Review" *New Zealand Treasury Working Paper,* 03/19.

Coe, P.J. & Nason, J.M. (1999) *"Long Run Monetary Neutrality in Three Samples: The United Kingdom, The United States and the Small Sample"* Unpublished manuscript, University of Carlgary and University of British Colombia.

Conway, P. (1998) "Macroeconomic Variability in New Zealand: A SVAR study" *New Zealand Economic Papers*, 32(2), 161-186.

Cooley, T.F & Stephen, F.L. (1985) "Atheoretical Macroeconomics: A Critique" *Journal of Monetary Economics*, Nov, 283-308.

Crosby, M. & Otto, G. (2000) "Inflation and the Capital Stock" *Journal of Money, Credit, and Banking,* 32(2), 236-253.

Dalziel, P. (1991) "Theoretical Approaches to Monetary Disinflation" *Journal of Economic Surveys*, 5(4), 329-357.

Dalziel, P. (1993) "The Reserve Bank Act" in B. Roper & C, Rudd (eds) *"State and Economy in New Zealand"*, Auckland: Oxford University Press.

Dalziel, P. (1999) "New Zealand's Economic Reform Programme was a Failure" Unpublished Paper, Department of Economics and Marketing, Lincoln University, New Zealand.

Dalziel, P. (2001) *"Money, Credit and Price Stability"* London: Routledge.

Dalziel, P. (2002) "Monetary Policy and the Exchange Rate" *New Zealand Association of Economists,* 36(2), 199-207.

Dalziel, P. & Lattimore, R. (2001) *"The New Zealand Macroeconomy: A Briefing on the Reforms and their Legacy"* Auckland: Oxford University Press.

Deane, R.S., Nicholl, P.E. & Smith, R.G. (eds) (1983) *"Monetary Policy and the New Zealand Financial System"* 2nd ed., Wellington: Reserve Bank of New Zealand.

Debs, A. (2001) "Testing for a Structural Break in the Volatility of Real GDP Growth in Canada" *Bank of Canada Working Paper,* 2001-9.

Deutsche Bundesbank (2002) "Monetary Policy and Investment Behaviour –An Empirical Study", *Monthly Report of the Deutsche Bundesbank,* 54(7), 41-54.

Doganlar, M. (1998) "Testing for the Structural Break in the Turkish Foreign Trade" Unpublished Paper, Department of Economics, Faculty of Economics and Administrative Sciences, University of Cukurova, Turkey. Retrieved 13th July 2003 from World Wide Web: http://www.econturk.org/Turkey98.html

Dotsey, M. (1999) "The Importance of Systematic Monetary Policy for Economic Activity" *Federal Reserve Bank of Richmond Economic Quarterly,* 85(3), 41-57.

Driffill, J., Mizon, G.E. & Ulph, A. (1990) "Costs of Inflation" in B.M. Friedman & F.H. Hahn (eds) *Handbook of Monetary Economics*, Vol. 2, Amsterdam: North-Holland.

Dungey, M. & Pagan, A. (2000) "A Structural VAR Model of the Australian Economy" *The Economic Record*, 76(235), 321-342.

Dwyer, G.P. & Hafer, R.W. (1999) "Are Money Growth and Inflation Still Related?" *Federal Reserve Bank of Atlanta Economic Review*, 2nd Quarter 1999, 32-43.
Enders, W. (1995) "*Applied Econometric Time Series*" New York: John Wiley & Sons.
Enders, W. (1996) "*RATS: Handbook for Econometric Time Series*" New York: John Wiley & Sons.
Enderwick, P. & Akoorie, M. (1994) "Internationalization of Business and the New Zealand Economy" in J. Deeks & P. Enderwick (eds) "*Business and New Zealand Society*" Auckland: Longman Paul.
Engelbrecht, H. & Loomes, R. (2002) "The Unintended Consequences of Using an MCI as an Operational Monetary Policy Target in New Zealand: Suggestive Evidence from Rolling Regressions" *New Zealand Economic Papers*, 36(2), 217-233.
Engle, R.F., Hendry, D.F. & Richard, J. (1983) "Exogeneity" *Econometrica*, 51(2), 277-304.
Erden, L. (2002) "The Effects of Financial Markets on Private Capital Formation: An Empirical Analysis of the Turkish Data over 1968-1998 Period" Unpublished Paper, Mersin University, Turkey. Retrieved 10August 2003 from World Wide Web: http://www.econ.utah.edu/ehrbar/erc2002/pdf/P086.pdf
Ericsson, N.R., Hendry, D.F. & Mizon, G.E. (1998) "Exogeneity, Cointegration, and Economic Policy Analysis" *American Statistical Association Journal of Business & Economic Statistics*, 16(4), 370-387.
Estrella, A. (2002) "Securitisation and the Efficacy of Monetary Policy" Federal Reserve Bank of New York *Economic Policy Review*, May, 243-255.
Evans, L., Grimes, A., Wilkinson, B. & Teece, D. (1996) "Economic Reform in New Zealand 1984-95: The Pursuit of Efficiency" *Journal of Economic Literature*, Vol. XXXIV, December, 1856-1902.
Fackler, J. S. & Rogers, J.H. (1993) "An Empirical Open-Economy Macro Model with Credit" *Journal of Macroeconomics*, 15(2), 203-224.
Faust, J. & Rogers, J.H. (2002) "Monetary Policy's Role in Exchange Rate Behavior" Unpublished Paper, International Finance Division, Federal Reserve Board, Washington, D.C., 20551. Retrieved 10th September 2003 from World Wide Web: http://patriot.net/-faustj/jon/pdf/os.pdf
Faust, J., Rogers, J.H., Swanson, E. & Wright, J.H. (2002) "Identifying the Effects of Monetary Policy Shocks on Exchange Rates Using High Frequency Data" *International Finance Discussion Papers* 739, Federal Reserve System. Retrieved 21st September 2003 from World Wide Web: http://www.federalreserve.gov/pubs/ifdp/2002/739/ifdp739.pdf
Favara, G. & Giordani, P. (2002) "Reconsidering the Role of Money for Output, Prices and Interest Rates" *SSE/EFI Working Paper Series in Economics and Finance*, 514.
Fish, M.E. & Seater, J.J. (1993) "Long-Run Neutrality and Superneutrality in an ARIMA Framework," *American Economic Review*, 83(3), 402-415.
Franses, P.H. (1996) *"Periodicity and Stochastic Trends in Economic Time Series"* New York: Oxford University Press.
Franses, P.H. (1998) *"Time-Series Models for Business and Economic Forecasting"* Cambridge: Cambridge University Press.
Friedman, B.M. (1990) "Targets and Instruments of Monetary Policy" in B.M. Friedman & F.H. Hahn (eds) *Handbook of Monetary Economics*, Vol. 2,Amsterdam: North-Holland.

Friedman, B.M. (2000) "Monetary Policy" National Bureau of Economic Research Working Paper 8057. Retrieved 20 March 2003 from the World Wide Web: http://www.nber.org/papers/w8057

Friedman, M. (1968) "The Role of Monetary Policy" *The American Economic Review,* LVIII, 1-17.

Friedman, M. (1969) "*The Optimum Quantity of Money and Other Essays*" London: Macmillan.

Friedman, M. (1995) "Quantity Theory of Money" in M.Blaug, W.Eltis, D. O'brien, D. Patinkin, & R. Skidelsky (eds) *The Quantity Theory of Money: From Locke to Keynes and Friedman,* Aldershot: Edward Elgar.

Galbraith, J.K. (1975) "*Money: Whence it came, where it went*" London: Andre Deutsch.

Gale, D. (1982) "Money: In Equilibrium" In F.H.Hahn (ed.) *The Cambridge Economic Handbooks,* Digswell Place, Welwyn: James Nisbet & Co. Ltd.

Gale, D. (1983) "Money: in disequilibrium" In F.H.Hahn (ed.) *The Cambridge Economic Handbooks,* Digswell Palce, Welwyn: James Nisbet & Co. Ltd.

Ghatak, S.(1995)"*Monetary Economics in Developing Economics*" 2nd ed., New York: St. Martin's Press.

Giordani, P. (2001a) "An Alternative Explanation of the Price Puzzle" *SSE/EFI Economics and Finance Paper,* 414.

Giordani, P. (2001b) "Stronger Evidence of Long-Run Neutrality: A Comment on Bernanke and Mihov" *SSE/EFI Economics and Finance Paper*, 441.

Granger, W.J. (1969) "Investigating Causal Relations by Econometric Models and Cross-Spectral Method" *Econometrica*, 37(3), 424-438.

Green, W.H. (1993) "*Econometric Analysis*" 2nd ed., New York: Macmillan.

Gruen, D., Romalis, J. & Chandra, N. (1999) "The Lags of Monetary Policy" *The Economic Record*, 75(230), 280-94.

Guender, A.V. & Matheson, T.D. (2002) "Design Flaws in the Construction of Monetary Conditions Indices? A Cautionary Note" *New Zealand Economic Papers*, 36(2), 209-215.

Guttmann, R. (1994) "*How Credit-Money Shapes the Economy*" New York: M.E. Sharpe.

Hafer, R.W. & Jansen, D.W. (1990) "The Demand for Money in the United States: Evidence from Cointegration Tests" *Journal of Money, Credit and Banking*, 23(2), 155-168.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (1998) "*Multivariate Data Analysis*" 5th ed., Prentice Hall.

Haliassos, J. & Tobin, J. (1990) "The Macroeconomics of Government Finance" in B.M.Friedman & F.H.Hahn (eds) *Handbook of Monetary Economics*, Vol. 2, Amsterdam: North-Holland.

Hall, S. (2001) "Credit Channel Effects in the Monetary Transmission Mechanism" *Bank of England Quarterly Bulletin*, 41(4), 442-448.

Haug, A.A & Lucas R.F. (1997) "Long-Run Neutrality and Superneutrality in an ARIMA Framework: Comment" *American Economic Review,* Dec., 756-59.

Hayo, B. (1999) "Money-Output Granger Causality Revisited: An Empirical Analysis of EU countries" *Applied Economics*, 3(11), 1489-1509.

Hubrich, K. & Vlaar, P. (2000) "Germany and the Euro area: Differences in the Transmission Process of Monetary Policy" Paper for the Econometric Society World Congress 2000, No. 1802. Retrieved 10th February 2003 from the World Wide Web: http:fmwww.bc.edu/RePEc/es2000/1802.pdf

Hudson, A. & Nelson, R. (1982) *"University Physics"*, New York: Harcourt Brace Jovanovich.

Hunt, B. & Orr, A. (eds) (1998) *"Proceedings of a Workshop on Monetary Policy Under Uncertainty"* Wellington: Reserve Bank of New Zealand.

Hillier, B.(1991) *"The Macroeconomic Debate: Models of the Closed and Open Economy"* Oxford: Blackwell.

Holtemoller, O. (2002) "Identifying a Credit Channel of Monetary Policy Transmission and Empirical Evidence for Germany" Unpublished Paper, Humboldt University, Berlin. Retrieved 10 July 2003 from World Wide Web: http://www.eea-esem.com/papers/eea-esem/esem2002/669/Crch-ger.pdf

Ibrahim, M.H. (2003) "International Disturbances and Domestic Macroeconomic Fluctuations in Malaysia" *Asean Economic Bulletin*, 20(1), 11-30.

International Monetary Fund (1998) "Inflation Targeting as a Framework for Monetary Policy" *Economic Issues* 15.

Jha, R. & Donde, K. (2001) "The Real Effects of Anticipated and Unanticipated Money: A Test of the Barro Proposition in the Indian Context" *The Indian Economic Journal*, 49(1). Retrieved 3 March 2003 from World Wide Web: http://www.indianeconomics.org/material/j-s-01-3.pdf

Johnston, J. & DiNardo, J. (1997) *"Econometric Methods"* 4th ed., New York: McGraw-Hill.

Justiniano, A. (2003) "Sources and Propagation Mechanisms of Foreign Disturbances in Small Open Economies: A Dynamic Factor Analysis" Unpublished manuscript, Princeton University. Retrieved 15th August 2003 from World Wide Web: http://www.princeton.edu/□jalejand

Kahn, J.A., McConnell, M.M. & Perez-Quiros, G. (2002) "On the Causes of the Increased Stability of the U.S. Economy" Federal Reserve Bank of New York Economic Policy Review, May, 183-202.

Kake, J. (2000) *"Monetary Transmission in Europe: The Role of the Financial Markets and Credit"* Edward Elgar.

Kamas, L. & Joyce, J.P. (1993) "Money, Income and Prices under Fixed Exchange Rates: Evidence from Causality Tests and VARs" *Journal of Macroeconomics*, 15(4), 747-768.

Kamin, S.B.& Klau, M. (1997) "Some Multi-Country Evidence on the Effects of Real Exchange Rates on Output" *Bank for International Settlements Working Paper* 48, Monetary and Economic Department, BASLE. Retrieved 3rd October 2002 from World Wide Web: http://www.bis.org/publ/work48.pdf

Kashyap, A.K. & Stein, J.C. (2000) "What Do A Million Observations on Banks Say About the Transmission of Monetary Policy" *The American Economic Review*, 90(3). Retrieved 11 June 2003 from World Wide Web: http://gsbwww.unchicago.edu/fac/anil.Kashyap/research/recall.pdf

Keating, J.W. (1992) "Structural Approaches to Vector Autoregressions" *Federal Reserve Bank of St.Louis Bulletin*, Sep/Oct., 37-57.

Keynes, J.M. (1930) *"A Treatise on Money"* Vol. 1, London: Macmillan.

King, R.G. & Watson, M.W. (1997). "Testing Long-Run Neutrality" Federal Reserve Bank of Richmond Economic Quarterly, 83(3), 69-101.

Kumah, F.Y. (1996) "The Effect of Monetary Policy on Exchange Rates: How to Solve the Puzzles" Unpublished Paper, CentER for Economic Research, Tilburg University, The Netherlands. Retrieved 5 June 2002 from World Wide Web: http://greywww.kub.nl:2080/greyfiles/center/1996/doc/70.pdf

Kuszczak, J. & Murray, J.D. (1987) "A VAR Analysis of Economic Interdependence: Canada, the United States, and the Rest of the World" Technical Report 46, Bank of Canada. Retrieved 12 June 2003 from World Wide Web: http://www.research.stlouisfed.org/publications/review/86/conf/murray.pdf

Kuttner, K.N. & Mosser, P.C. (2002) "The Monetary Transmission Mechanism: Some Answers and Further questions" Federal Reserve Bank of New York *Economic Policy Review,* 8(1), May, 15-26.

Leeper, E.M., Sims, C.A. & Zha, T. (1996) "What Does Monetary Policy Do?" *Brookings Papers on Economic Activity*, 2.

Leeper, E.M. & Roush, J.E. (2003) "Putting 'M' Back in Monetary Policy" Unpublished paper, Board of Governors of the Federal Reserve System *International Finance Discussion Papers,* No. 761.

Levacic, R. & Rebmann, A. (1982) *"Macroeconomics: An Introduction to Keynesian Neoclassical Controversies"*, London: Macmillan.

Lincoln University (2000) *"Presentation & Deposit of Theses and Dissertations; Library Requirements & Guidelines"* Library Paper No. 17, Lincoln University, Canterbury, New Zealand.

Litterman, R.B. & Weiss, L. (1983) "Money, Real Interest Rates, and Output: A Reinterpretation of Postwar U.S. Data" National Bureau of Economic Research Working Paper No. 1077, Feb.

Loo, C.M. & Lastrapes, W.D. (1998) "Identifying the Effects of Money Supply Shocks on Industry-level Output" *Journal of Macroeconomics*, 20(3), 431-449.

Lown, C.S. & Morgan, D.P. (2002) "Credit Effects in the Monetary Mechanism" *Federal Reserve Bank of New York Economic Policy Review*, 8(1), May, 217-235.

Lucas, R.E. (1996) "Nobel Lecture: Monetary Neutrality" *Journal of Political Economy,* Aug., 661-682.

Ludvigson, S., Steindel, C. & Lettau, M. (2002) "Monetary Policy Transmission Through the Consumption-Wealth Channel" *Federal Reserve Bank of New York Economic Policy Review*, 8(1), May, 117-133.

Lutkepohl, H. & Wolters, J. (2001) "The Transmission of Monetary Policy in the Pre-Euro Period" CESifo Working Paper No. 604. Retrieved 2 March 2003 from World Wide Web: http://www.CESifo.de.

Maddala, G.S. (2001) *"Introduction to Econometrics"* 3rd ed., Chichester: John Wiley & Sons.

Maddala, G.S. & Kim, I. (1998) *"Unit Roots, Cointegration, and Structural Change"* Cambridge: Cambridge University Press.

Mahadeva, L. & Sinclair, P. (eds) (2002) *"Monetary Transmission in Diverse Economies"* Cambridge: Cambridge University Press.

Machester, J. (1989) "How Money Affects Real Output" *Journal of Money, Credit, and Banking",* 21(1), 16-32.

Mankiw, N.G. (1998) *"Principles of Macroeconomics"* Fort Worth: The Dryden Press.

Mankiw, N.G. (2000) "The Inexorable and Mysterious Tradeoff Between Inflation and Unemployment" Working Paper 7884, National Bureau of Economic Research.

Marcellino, M. & Salmon, M. (1999) "Robust Decision Theory and the Lucas Critique" Unpublished Paper, University of Bocconi and City University Business School, London. Retrieved 3 October 2002 from World Wide Web: http://www.business.city.ac.uk/ferc/wpapers/lucas1.pdf

Mauskopf, E. (1990) "The Transmission Channels of Monetary Policy: How Have They Changed?" *Federal Reserve Bulletin,* 76(12), 985-1008.

McCallum, B.T. (1990) “Inflation: Theory and Evidence”, in B.M.Friedman & F.H.Hahn (eds) *Handbook of Monetary Economics*, Vol. 2, Amsterdam: North-Holland.

McCallum, B.T. (1999) *“Analysis of the Monetary Transmission Mechanism: Methodological Issues” Paper prepared for the Deutsche Bundesbank Conference 'The Monetary Transmission Process: Recent Developments and Lessons for Europe'*, Frankfurt, March 26-27, 1999.

McCallum, B.T. (2001) "Monetary Policy Analysis in Models Without Money" *Federal Reserve Bank of St.Louis Review*, July/August, 145-160.

McCarthy, J. & Peach, R.W. (2002) "Monetary Policy Transmission to Residential Investment" *Federal Reserve Bank of New York Economic Policy Review*, May, 139-151.

McCoy, D. & McMahon, M. (2000) "Differences in the Transmission of Monetary Policy in the Euro-Area: An Empirical Approach" Paper presented at the 14th Annual Conference of the Irish Economic Association, 1-3 April 2000, Waterford. Retrieved 10 September 2002 from World Wide Web: http://www.centralbank.ie/data/TechPaperFiles/5RT00.pdf

Meltzer, A.H. (1995) "Monetary ,Credit and (Other) Transmission Processes: A Monetarist Perspective" *Journal of Economic Perspectives*, 9(4), 49-72.

Meltzer, A.H. (1999) “The Transmission Process”, Unpublished Speech, Carnegie Mellon University and the American Enterprise Institute. Retrieved 6 September 2003 from World Wide Web://www.gsia.cmu.edu/afs/Andrews/gsia/meltzer/transmission.pdf

Meyer, L.H. (2001) “Does Money Matter?” Paper Prepared for the Homer Jones Lecture, Federal Reserve Bank of St Louis, March 28, 2001.

Mishkin, F.S. (1980) "Does Anticipated Monetary Policy Matter? An Econometric Investigation" Working Paper No. 506, National Bureau of Economic Research.

Mishkin, F.S. (1995) "Symposium on the Monetary Transmission Mechanism" *Journal of Economic Perspectives*, 9(4), 11-12.

Mishkin, F.S. (1998) "The Economics of Money, Banking, Financial Markets" 5th ed., Addison-Wesley.

Mojon, B., Smets, F. & Vermeulen, P. (2001) "Investment and Monetary Policy in The Euro Area" *European Central Bank Working Paper No.* 78, Oct.

Mojon, B. & Peersman, G. (2001) "A VAR Description of the Effects of Monetary Policy in the Individual Countries of the Euro Area" *European Central Bank Working Paper* No. 93, Dec.

Morsink, J. & Bayoumi, T. (2001) "A Peek Inside the Black Box: The Monetary Transmission in Japan" *IMF Staff Papers*, 48(1), 22-57.

Noriega, A.E. (2003) "Neutrality and superneutrality of Money in the Mexican Economy: Further Evidence Under Sequential Unit Root Testing" Unpublished Paper, Department of Econometrics, Universidad de Guanajuato, Mexico. Retrieved 10 October 2003 from World Wide Web: http://portal.ugto.mx/economia/doctors/neunajef1.pdf

Norrbin, S. (2000) "What Have We Learned From Empirical Tests of the Monetary Transmission Effect?" Unpublished Paper, Department of Economics, Florida State University. Retrieved 9th June 2003 from World Wide Web: http://www.riksbank.com/upload/4840/wp_121.pdf

Obstfeld, M. & Rogoff, K. (1995) “The Mirage of Fixed Exchange Rates” *Journal of Economic Perspectives*, 9(4), 73-96.

Oliner, S.D. & Rudebusch, G.D. (1996) "Is There Broad Credit Channel for Monetary Policy?" Retrieved 20 June 2003 from World Wide Web: http://www.sf.frb.org/econrsch/econrev/96-1/3-13.pdf

Orden, D. & Fisher, L.A. (1993) "Financial Deregulation and the Dynamics of Money, Prices, and Output in New Zealand and Australia" *Journal of Money, Credit, and Banking,* 25(2), 273-292.

Orphanides, A. & Solow, R.M. (1990) "Money, Inflation and Growth". in B.M. Friedman & F.H. Hahn (eds) *Handbook of Monetary Economics,* Vol.1, Amsterdam: North-Holland.

Pagan, A. (1984) "Econometric Issues in the Analysis of Regressions with Generated Regressors" *International Economic Review* 25(1), 221-247.

Papademos, L. & Modigliani, F. (1990) "The Supply of Income and the Control of Nominal Income" in B.M Friedman & F.H Hahn (eds) *Handbook of Monetary Economics*, Vol.1, Amsterdam: North-Holland.

Patinkin, D. (1956) *"Money, Interest, Prices"* Evanston, Illinois: Row, Peterson and Co.

Patinkin, D. (1989) "Neutrality of Money" in J. Eatwell, M. Milgate, & P. Newman (eds) *The New Palgrave: Money,* New York: W.W. Norton.

Patterson, K. (2000) *"An Introduction to Applied Econometrics: A Time Series Approach"* London: Macmillan Press.

Pearl, J. (1998) "Graphs, Causality, and Structural Equation Models" *Sociological Methods and Research,* 27(2), 226-284.

Peersman, G. & Smets, F. (2001) "The Monetary Transmission Mechanism in the Euro Area: More Evidence from VAR Analysis" *European Central Bank Working Paper No. 91.* December.

Peersman, G. & Smets, F. (2002) "The Industry Effects of Monetary Policy in the Euro Area" *European Central Bank Working Paper No. 165*, August.

Perez, S.J. (2002) "Monetary Policy Does Matter: Control Causality and Superneutrality" *Oxford Bulletin of Economics and Statistics*, 64(5), 473-484.

Perron, P. (1987) "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis" *Econometrica*, 57(6), 1361-1401.

Perron, P. (1997) "Further Evidence on Breaking Trend Functions in Macroeconomic Variables" *Journal of Econometrics*, 80, 355-385.

Perron, P. & Vogelsang, T.J (1993) "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis: Erratum" *Econometrica*, 61(1), 248-249.

Pesaran, M.H. & Pesaran, B. (1997) *"Working with Microfit 4.0: Interactive Economic Analysis"* Oxford: Oxford University Press.

Peterson, W.L.(1996) "Does Money Still Matter?" *Cato Journal*, 16(2), 253-265.

Podder, N. & Chatterjee, S. (1998) "Sharing the National Cake in Post Reform New Zealand: Income Inequality Trends in Terms of Income Sources" *Paper prepared for the Annual Conference of the New Zealand Association of Economists, Wellington, 2-4 September 1998.*

Quantitative Micro Software (2002) *"Eviews 4 User's Guide"* Irvine CA: Quantitative Micro Software.

Rabin, A.A. & Yeager, L.B. (1997) "The Monetary Transmission Mechanism" *Eastern Economic Journal,* 23(3), p 293-299.

Rapach, D.E. (1999) *"International Evidence on the Long-Run Superneutrality of Money"* Unpublished Manuscript, Trinity College, Washington, D.C.

Reserve Bank of Australia (2003) "About Monetary Policy" Retrieved 15 March 2003 from World Wide Web: http://www.rba.gov.au/MonetaryPolicy/about_monetary_policy.html

Reserve Bank of New Zealand (1955) *"Monetary and Fiscal Policy in New Zealand"* Wellington: Reserve Bank of New Zealand.

Reserve Bank of New Zealand (1997) *"The Impact of Monetary Policy on People"* May, Wellington: Reserve Bank of New Zealand.

Reserve Bank of New Zealand (1999) *"Monetary Policy Over the Business Cycle"* June, Wellington: Reserve Bank of New Zealand.

Reserve Bank of New Zealand (2003) "Monetary Policy Statement" September. Retrieved 8 November 2003 from World Wide Web: http://www.rbnz.govt.nz.

Romer, C.D. & Romer, D.H. (1990) "New Evidence on the Monetary Transmission Mechanism" *Brookings Papers on Economic Activity*, 1, 149-213.

Roos, N. & Russell, B. (2000) "The Exports Transmission Mechanism of Foreign Business Cycles to Australia" University of Dundee Discussion Papers in Economics No. 110, October.

Rosenberg, B. (1998) "Foreign Investment in New Zealand: The Current Position" in P. Enderwick (ed) *"Foreign Investment: The New Zealand Experience"* Palmerston North: The Dunmore Press.

Rousseas, S.W. (1972) *"Monetary Theory"* New York: Alfred A. Knopf.

Rudebusch, G.D. (1998) "Do Measures in a VAR Make Sense?" *International Economic Review*, 39(4), 907-931.

Rudebusch, G.D. (2003) "Assessing the Lucas Critique in Monetary Policy Models" Forthcoming in the Journal of Money, Credit, and Banking. Retrieved 13 November 2003 from World Wide Web: http://www.frbsf.org/economics/economists/grudebusch/lucas050finaljmcb.pdf

Runkle, D.E. (1987) "Vector Autoregressions and Reality" *Journal of Business & Economic Statistics*, 5(4), 128-133.

Samuelson, P.A. & Nordhaus, W.D. (1998) "Macroeconomics" 16th ed., Boston, Mass: Irwin/McGraw-Hill.

Sanyal, A. & Ward, B. (1995) *"Has the Structural Breaks Affected New Zealand Business Cycles?"* Department of Economics and Marketing, Lincoln University, New Zealand.

Scollay R & St John (2000) *"Macroeconomics and the Contemporary New Zealand Economy"* Pearson Education New Zealand Ltd.

Serletis, A. & King, M. (1993) "The Role of Money in Canada" *Journal of Macroeconomics*, 15(1), 91-107.

Serletis, A. & Koustas (1998) "International Evidence on the Neutrality of Money" *Journal of Money, Credit and Banking*, 30(1), 1-25.

Serletis, A. & Koustas (2001) "Monetary Aggregation and the Neutrality of Money" *Economic Inquiry*, 39(1), 124-138.

Sheskin, D.J. (2000) *"Handbook of Parametric and Non-parametric Statistical Procedures"* 2nd ed., Chapman and Hall/CRC Press.

Sidrauski, M. (1967) "Inflation and Economic Growth" *The Journal of Political Economy*, 75(6), 796-810.

Sims, C.A. (1972) "Money, Income and Causality" *American Economic Review*, 62, 540-552.

Sims, C.A. (1980) "Macroeconomics and Reality" *Econometrica*, 48, 1-48.

Siregar, H. (2001) "Empirical Evaluation of Rival Theories of The Business Cycle: Applications of Structural VAR Models to the New Zealand Economy" Unpublished PhD Thesis, Lincoln University, New Zealand.

Siregar, H. & Ward, B.D. (2000) "Long Run Money Demand, Long Run Spending Balance, and Macroeconomic Fluctuations: Application of a cointegrated SVAR model to the Indonesian Economy" *International Economics*, LIV (3).

Smets, F. & Wouters, R. (1999) "The Exchange Rate and the Monetary Transmission Mechanism in Germany" *De Economist*, 147(4), 489-521.

Snowdon, B., Vane, H. & Wynarczyk, P. (1994) *"A Modern Guide to Macroeconomics: An Introduction to Competing Schools of Thoughts"* Cheltenham: Edward Elgar.

Solow, R.M. (1956) "A Contribution to the Theory of Economic Growth" *The Quarterly Journal of Economics*, LXX(1), 65-94.

Stein, J.L (1970) "Monetary Growth in Perspective", *American Economic Review*, 60, 85-106.

Stein, J.L (1982) *"Monetarist, Keynesian, and New Classical Economics"*, New York: New York University Press.

Steinhauer, L. & Chang, J. (1972) "On Measuring the Nearness of Near-Moneys: Comment" *The American Economic Review*, 62(1), 221-225.

Stewart, M. (1972) "Keynes and After" 2nd ed., Middlesex: Penguin Books.

Stock, J.H. & Watson, M.W. (2001) "Vector Autoregressions" *Journal of economic Perspectives*, 15(4), 101-115.

Summers, L.H. (1991) "The Scientific Illusion in Empirical Macroeconomics" *Scandanavian Journal of Economics*, 93(2), 129-148.

Suzuki, T. (2001) *"Is the Lending Channel of Monetary Policy Important in Australia?"* Unpublished Paper, Faculty of Economics and Commerce, Australian National University, Australia.

Taylor, J.B. (1995) "The Monetary Transmission Mechanism: An Empirical Framework" *Journal of Economic Perspectives*, 9(4), 11-26.

Taylor, J.B. (2000) "The Role of the Exchange Rate in Monetary Policy Rules", mimeo, Stanford University. Retrieved 6 June 2003 from World Wide Web: http://www.standford.edu/-johntayl/Papers/AEA2001ExchRate.pdf

Telford, K.W. (1997) *"Monetary Transmission in New Zealand: A VAR Model"* Unpublished Master's Thesis, Lincoln University, New Zealand.

Thomas, R.L (1993) *"Introductory Economics: Theory and Applications"* New York: Longman Group.

Tintner, G. (1952) *"Econometrics"* John Wiley and Sons.

Tobin, J. (1965) "Money and Economic Growth" *Econometrica*, 33(4), 671-684.

Ueda, K. (2002 "The Transmission Mechanism of Monetary Policy Near Zero Interest Rates: The Japanese Experience, 1998-2000" in L. Mahadeva & P. Sinclair (eds) *Monetary Transmission in Diverse Economies*, Cambridge: Cambridge University Press.

Uselton, G.C. (1974) *"Lags in the Effects of Monetary Policy: A Nonparametric Analysis"* New York: Marcel Dekker.

Heuvel, S.J. (2002) "Does Bank Capital Matter For Monetary Transmission?" *Federal Reserve Bank of New York Economic Policy Review*, May, 259-265.

Verbeek, M. (2000) *"A Guide to Modern Econometrics"* Chichester: John Wiley & Sons

Volcker, P.A. (2002) "Monetary Policy Transmission: Past and Future Challenges" Federal Reserve Bank of New York *Economic Policy Review*, May, 7-11.

Walters, A.A. (1973) "Money and banking: selected readings" Harmondsworth: Penguin.

Ward, B. (1996) "*Econometric Modelling Analysis*" Unpublished ECON307/612 notes, Department of Economics and Marketing, Lincoln University, New Zealand.

Warner, E.J. & Georges, C. (2001) "The Credit Channel of Monetary Policy Transmission: Evidence from Stock Returns" *Economic Inquiry*, 39(1), 74-85.

Wongsaart, P. (2002) "An Analysis of the Transmission Mechanism of Monetary Policy in New Zealand: Evidence from SVAR Analysis", Unpublished Paper, Commerce Division, Lincoln University, New Zealand. Retrieved 5th October 2003 from World Wide Web: http://nzae.org.nz/files/%2327.wongsaart.pdf

Zivot, E. & Andrews, D.W.K. (1992) "Further Evidence on the Great Crash, the Oil Price Shock, and the Unit-Root Hypothesis" *Journal of Business and Economic Statistics,* 10(3), 251-270.

Zellner, A. (1984) *"Basic Issues in Econometrics"* Chicago: The University of Chicago Press.

APPENDICES

APPENDIX 6.1 CORRELATION COEFFICIENTS

Table A6.1: Correlation coefficients

a) New Zealand (in level)

	M1	M3	INT	EXCH	PE	KF	EXPT	PCE	CRED	CPI	GDPR	GDPN
M1	1.000	0.962	-0.809	-0.570	0.795	0.782	0.943	0.901	0.979	0.889	0.919	0.959
M3	0.962	1.000	-0.838	-0.472	0.852	0.831	0.971	0.895	0.992	0.910	0.946	0.973
INT	-0.809	-0.838	1.000	0.572	-0.578	-0.540	-0.843	-0.573	-0.820	-0.881	-0.721	-0.840
EXCH	-0.570	-0.472	0.572	1.000	-0.303	-0.157	-0.494	-0.381	-0.524	-0.443	-0.401	-0.461
PE	0.795	0.852	-0.578	-0.303	1.000	0.853	0.837	0.855	0.854	0.668	0.894	0.816
KF	0.782	0.831	-0.540	-0.157	0.853	1.000	0.794	0.856	0.829	0.655	0.912	0.818
EXPT	0.943	0.971	-0.843	-0.494	0.837	0.794	1.000	0.866	0.971	0.877	0.929	0.956
PCE	0.901	0.895	-0.573	-0.381	0.855	0.856	0.866	1.000	0.913	0.743	0.913	0.876
CRED	0.979	0.992	-0.820	-0.524	0.854	0.829	0.971	0.913	1.000	0.887	0.951	0.965
CPI	0.889	0.910	-0.881	-0.443	0.668	0.655	0.877	0.743	0.887	1.000	0.789	0.935
GDPR	0.919	0.946	-0.721	-0.401	0.894	0.912	0.929	0.913	0.951	0.789	1.000	0.945
GDPN	0.959	0.973	-0.840	-0.461	0.816	0.818	0.956	0.876	0.965	0.935	0.945	1.000

(in first-difference)

	DM1	DM3	DINT	DEXCH	DPE	DKF	DEXPT	DPCE	DCRED	DCPI	DGDPR	DGDPN
DM1	1.000	0.043	-0.206	0.002	0.171	0.030	0.266	0.097	0.094	-0.003	0.419	0.459
DM3	0.043	1.000	0.127	0.060	-0.044	0.026	0.002	-0.032	0.690	0.158	0.069	0.008
DINT	-0.206	0.127	1.000	0.219	-0.079	0.004	0.015	0.169	0.063	0.153	-0.132	-0.108
DEXCH	0.002	0.060	0.219	1.000	0.152	-0.137	0.051	-0.212	0.050	0.141	-0.122	-0.137
DPE	0.171	-0.044	-0.079	0.152	1.000	-0.020	0.029	-0.083	-0.058	0.049	-0.031	-0.010
DKF	0.030	0.026	0.004	-0.137	-0.020	1.000	-0.286	0.085	-0.065	0.032	0.412	0.349
DEXPT	0.266	0.002	0.015	0.051	0.029	-0.286	1.000	0.179	0.029	-0.189	0.015	0.338
DPCE	0.097	-0.032	0.169	-0.212	-0.083	0.085	0.179	1.000	-0.005	-0.287	0.144	0.114
DCRED	0.094	0.690	0.063	0.050	-0.058	-0.065	0.029	-0.005	1.000	0.045	0.065	-0.007
DCPI	-0.003	0.158	0.153	0.141	0.049	0.032	-0.189	-0.287	0.045	1.000	0.026	0.029
DGDPR	0.419	0.069	-0.132	-0.122	-0.031	0.412	0.015	0.144	0.065	0.026	1.000	0.864
DGDPN	0.459	0.008	-0.108	-0.137	-0.010	0.349	0.338	0.114	-0.007	0.029	0.864	1.000

b) Australia (in level)

	M1	M3	INT	EXCH	PE	KF	EXPT	PCE	CRED	CPI	GDPR	GDPN
M1	1.000	0.990	-0.780	-0.511	0.952	0.926	0.979	0.981	0.982	0.913	0.970	0.977
M3	0.990	1.000	-0.800	-0.497	0.938	0.915	0.985	0.997	0.993	0.954	0.971	0.991
INT	-0.780	-0.800	1.000	0.591	-0.702	-0.614	-0.828	-0.821	-0.753	-0.843	-0.751	-0.797
EXCH	-0.511	-0.497	0.591	1.000	-0.470	-0.318	-0.502	-0.515	-0.476	-0.526	-0.477	-0.503
PE	0.952	0.938	-0.702	-0.470	1.000	0.941	0.942	0.931	0.949	0.842	0.937	0.929
KF	0.926	0.915	-0.614	-0.318	0.941	1.000	0.910	0.902	0.925	0.808	0.925	0.906
EXPT	0.979	0.985	-0.828	-0.502	0.942	0.910	1.000	0.984	0.972	0.936	0.960	0.974
PCE	0.981	0.997	-0.821	-0.515	0.931	0.902	0.984	1.000	0.991	0.970	0.965	0.991
CRED	0.982	0.993	-0.753	-0.476	0.949	0.925	0.972	0.991	1.000	0.943	0.966	0.986
CPI	0.913	0.954	-0.843	-0.526	0.842	0.808	0.936	0.970	0.943	1.000	0.912	0.962
GDPR	0.970	0.971	-0.751	-0.477	0.937	0.925	0.960	0.965	0.966	0.912	1.000	0.987

(in first-difference)

	DM1	DM3	DINT	DEXCH	DPE	DKF	DEXPT	DPCE	DCRED	DCPI	DGDPR	DGDPN
DM1	1.000	0.707	0.010	0.102	0.070	0.036	-0.129	0.101	0.112	-0.119	0.666	0.712
DM3	0.707	1.000	0.144	0.099	-0.022	0.188	-0.022	0.267	0.316	0.090	0.449	0.477
DINT	0.010	0.144	1.000	0.031	-0.100	0.069	-0.064	0.171	0.286	0.093	0.083	0.072
DEXCH	0.102	0.099	0.031	1.000	0.222	0.196	-0.206	-0.107	0.088	-0.191	-0.071	-0.040
DPE	0.070	-0.022	-0.100	0.222	1.000	-0.037	-0.013	0.005	-0.047	-0.042	0.017	0.056
DKF	0.036	0.188	0.069	0.196	-0.037	1.000	-0.077	-0.051	0.131	-0.394	-0.013	-0.048
DEXP	-0.129	-0.022	-0.064	-0.206	-0.013	-0.077	1.000	0.061	-0.045	0.085	-0.013	-0.033
DPCE	0.101	0.267	0.171	-0.107	0.005	-0.051	0.061	1.000	0.503	0.378	-0.070	-0.047
DCRED	0.112	0.316	0.286	0.088	-0.047	0.131	-0.045	0.503	1.000	0.223	-0.061	-0.017
DCPI	-0.119	0.090	0.093	-0.191	-0.042	-0.394	0.085	0.378	0.223	1.000	0.055	0.093
DGDPR	0.666	0.449	0.083	-0.071	0.017	-0.013	-0.013	-0.070	-0.061	0.055	1.000	0.983

APPENDIX 6.2: UNIT ROOT TEST RESULTS

Table A6.2.1 Unit root test results

t-statistics (prob)

a) 1977-2001 Sample

Variable	ADF test (Ho: Nonstationary)			PP test (Ho: Nonstationary)			KPPS test[2] (Ho: Stationary)	
	Const & linear trend τ_τ	Const τ_u	None τ	Const & linear trend τ_τ	Const τ_u	None τ	Const & linear trend τ_τ	Const τ_u
GDPR	-1.1 (0.928)	0.7(0.992)	2.5(0.997)	-5.6(0.000)	0.0(0.956)	3.2(0.999)	0.257	1.255
GDPN	-3.6(0.035)	-0.0(0.953)	1.4(0.955)	-7.3(0.000)	0.1(0.960)	3.7(0.999)	0.133	1.334
GDP[1]	-3.6(0.035)	-3.6(0.007)	-3.6(0.000)	-7.3(0.000)	-7.3(0.000)	-7.4(0.000)	0.133	0.133
M1	0.9(0.955)	1.6(0.999)	2.9(0.999)	-0.6(0.975)	6.1(1.000)	13(1.000)	0.185	1.288
M3	-1.0(0.942)	2.8(1.000)	6.8(1.000)	-0.8(0.964)	2.8(1.000)	7.5(1.000)	0.288	1.326
CPI	-0.4(0.987)	-2.2(0.202)	1.6(0.973)	-0.3(0.990)	-2.2(0.197)	3.6(0.999)	0.311	1.285
INT	-2.7(0.262)	-1.4(0.586)	-0.7(0.412)	-2.3(0.423)	-1.0(0.747)	-0.6(0.439)	0.217	0.786
INF	-5.6(0.000)	-2.7(0.077)	-2.1(0.036)	-5.6(0.000)	-3.5(0.009)	-2.4(0.018)	0.100	1.038
DGDPR	-3.0(0.128)	-2.9(0.056)	-1.6(0.107)	-21(0.000)	-19(0.000)	-13(0.000)	0.070	0.187
DGDPN	-2.8(0.187)	-2.9(0.055)	-0.4(0.532)	-29(0.000)	-27(0.000)	-16(0.000)	0.064	0.074
DM1	-3.9(0.017)	-3.3(0.017)	-2.2(0.030)	-12(0.000)	-12(0.000)	-10(0.000)	0.189	0.400
DM3	-11.5(0.000)	-5.3(0.000)	-3.5(0.001)	-11(0.000)	-11(0.000)	-9(0.000)	0.045	0.712
DCPI	-5.7(0.000)	-3.6(0.008)	-2.1(0.034)	-6.0(0.000)	-5.0(0.000)	-3.0(0.004)	0.130	0.553
DINT	-6.3(0.000)	-6.3(0.000)	-6.3(0.000)	-6.0(0.000)	-6.0(0.000)	-6.0(0.000)	0.074	0.229
DINF	-14(0.000)	-14(0.000)	-14(0.000)	-19(0.000)	-19(0.000)	-19(0.000)	0.081	0.087

b) 1985-2001 Sample

EXCH	-2.1(0.520)	-1.7(0.430)	-0.6(0.430)	-2.3(0.440)	-1.8(0.380)	0.6(0.430)	0.096	0.35
PE	-2.3(0.420)	-1.1(0.710)	0.8(0.870)	-2.4(0.390)	-1.0(0.750)	0.9(0.900)	0.175	0.880
EXPT	-2.2(0.490)	0.9(1.000)	3.9(1.000)	-6.1(0.000)	0.9(1.000)	4.3(1.000)	0.293	1.074
CRED	1.5(1.000)	4.7(1.000)	9.4(1.000)	1.7(1.000)	4.5(1.000)	13(1.000)	0.270	1.067
PCE	-2.1(0.510)	0.8(0.810)	1.6(0.970)	-2.0(0.600)	0.6(0.860)	1.9(1.000)	0.211	0.916
KF	-2.6(0.300)	-0.5(0.890)	0.9(0.900)	-3.1(0.110)	-1.8(0.390)	1.0(0.900)	0.162	0.836
DEXCH	-8.6(0.000)	-8.6(0.000)	-8.7(0.000)	-8.6(0.000)	-8.6(0.000)	-8.7(0.00)	0.058	0.072
DPE	-9.0(0.000)	-9.1(0.000)	-9.0(0.000)	-9.1(0.000)	-9.1(0.000)	-9.0(0.00)	0.050	0.069
DEXPT	-5.0(0.002)	-5.4(0.000)	-2.0(0.015)	-17(0.000)	-15(0.000)	-10(0.00)	0.092	0.344
DCRED	-11(0.000)	-3.0(0.061)	0.8(0.880)	-11(0.000)	-9.0(0.000)	-5(0.000)	0.181	0.936
DPCE	-10.0.000)	-10(0.00)	-10(0.000)	-10(0.000)	-10(0.000)	-10(0.00)	0.076	0.103
DKF	-3.7(0.030)	-3.6(0.010)	-3.5(0.000)	-18(0.000)	-15(0.000)	-12(0.00)	0.147	0.147

Notes: [1] de-trended series; [2] For the KPPS critical values, these are provided in the footnote for Table A6.2.2.

Table A6.2.2 Aust: Unit root test results

t-statistics (prob)

Variable	ADF test (Ho: Nonstationary)			PP test (Ho: Nonstationary)			KPPS test[2] (Ho: Stationary)	
	Const & linear trend	Const	None	Const & linear trend	Const	None	Const & linear trend	Const
	τ_τ	τ_u	τ	τ_τ	τ_u	τ	τ_τ	τ_u
GDPR	-1.3(0.883)	1.2(1.000)	3.1(1.000)	-7.2(0.000)	-1.3(0.638)	2.9(1.000)	1.070	0.299
GDPN	-1.4(0.838)	0.8(1.000)	2.0(1.000)	-6.2(0.000)	-0.4(0.902)	4.7(1.000)	1.080	0.201
M1	1.4(1.000)	3.5(1.000)	3.7(1.000)	2.2(1.000)	13(1.000)	26(1.000)	1.068	0.267
M3	0.8(1.000)	3.4(1.000)	11.2(1.000)	0.8(1.000)	3.3(1.000)	11(1.000)	1.081	0.225
CPI	-2.4(0.387)	-1.6(0.480)	2.2(0.992)	-2.3(0.441)	-2.3(0.180)	4.8(1.000)	1.050	0.220
INT	-2.3(0.403)	-1.3(0.631)	-1.6(0.110)	-2.3(0.454)	-1.3(0.634)	-1.4(0.135)	0.882	0.132
INF	-1.6(0.787)	-1.6(0.450)	-1.4(0.153)	-2.5(0.338)	-1.6(0.459)	-1.0(0.268)	0.632	0.154
EXCH	-9.1(0.000)	-9.1(0.000)	-9.1(0.000)	-9.2(0.000)	-9.2(0.000)	-9.2(0.000)	0.118	0.072
PE	-1.6(0.768)	-0.3(0.916)	2.2(0.993)	-2.1(0.546)	-0.4(0.901)	2.3(0.99)	0.980	0.220
EXPT	-2.9(0.170)	0.2(0.969)	3.9(1.000)	-2.8(0.195)	0.5(0.986)	5.1(1.0)	1.074	0.214
CRED	-0.99(0.937)	1.0(0.996)	2.1(0.990)	-0.15(0.993)	1.7(1.000)	7.2(1.0)	1.048	0.200
PCE	1.1(1.000)	2.6(1.000)	17.2(1.0)	0.62(1.000)	2.1(1.000)	12.4(1.0)	1.086	0.170
KF	-1.9(0.648)	-0.3(0.926)	1.6(0.973)	-1.9(0.659)	-.08(0.947)	1.8(0.981)	0.926	0.182
DGDPR	-3.5(0.049)	-3.1(0.030)	-0.7(0.411)	-32(0.000)	-30(0.000)	-14(0.000)	0.082	0.085
DGDPN	-2.1(0.542)	-1.9(0.331)	-0.2(0.611)	-24(0.000)	-23(0.000)	-13(0.000)	0.089	0.089
DM1	-1.4(0.849)	-0.2(0.930)	1.0(0.913)	-10.9(0.000)	-8.8(0.000)	-6.3(0.000)	0.963	0.205
DM3	-7.4(0.000)	-6.5(0.000)	0.34(0.781)	-7.4(0.000)	-6.5(0.000)	-3.2(0.000)	0.703	0.141
DCPI	-3.4(0.062)	-3.3(0.020)	-1.9(0.061)	-6.2(0.000)	-5.8(0.000)	-2.9(0.000)	0.388	0.146
DINT	-7.5(0.000)	-7.5(0.000)	-7.4(0.000)	-7.6(0.000)	-7.6(0.000)	-7.6(0.000)	0.060	0.054
DINF	-4.8(0.001)	-4.8(0.000)	-4.8(0.000)	-7.2(0.000)	-7.3(0.000)	-7.3(0.000)	0.083	0.087
DPE	-11(0.000)	-11(0.000)	-11(0.000)	-12(0.000)	-12(0.000)	-11(0.000)	0.106	0.082
DEXPT	-8.6(0.00)	-8.6(0.000)	-8.6(0.000)	-8.8(0.000)	-8.7(0.000)	-7.0(0.000)	0.149	0.096
DCRED	-2.4(0.367)	-2.1(0.251)	-0.7(0.414)	-2.3(0.431)	-2.1(0.251)	-0.4(0.532)	0.374	0.158
DPCE	-2.6(0.294)	-2.0(0.278)	0.6(0.838)	-7.9(0.000)	-7.5(0.000)	-1.3(0.193)	0.442	0.202
DKF	-6.0(0.00)	-6.0(0.000)	-5.7(0.000)	-6.1(0.000)	-6.1(0.000)	-5.8(0.000)	0.133	0.055
DDM1	-16(0.000)	-16(0.000)	-16(0.000)	-47(0.000)	-47(0.000)	-43(0.000)	0.146	0.114
DDCRED	-9.9(0.000)	-9.9(0.000)	-9.9(0.000)	-10(0.000)	-10(0.000)	-10(0.000)	0.084	0.066
DDPCE	-6.5(0.000)	-6.4(0.000)	-6.4(0.000)	-17(0.000)	-17(0.000)	-17(0.000)	0.140	0.053

Note : [2] KPPS critical values:

	τ_τ	τ_u
1%	0.216	0.739
5%	0.146	0.463
10%	0.119	0.347

Table A6.2.3 Seasonal unit root test results

a) Dependent variable is real GDP

Variables	Coeff	t-stat	Prob.
Const	170	0.26	0.794
D2	293	0.89	0.372
D3	363	1.27	0.208
D4	1416	4.83	0.000
γ	5.97	1.39	0.166
π_1	-0.011	-1.06	0.292
π_2	0.376	-3.13	0.002
π_3	0.172	-1.72	0.089
π_4	0.398	-4.00	0.000

b) Dependent variable is nom GDP

Variables	Coeff	t-stat	Prob.
const	645	2.53	0.013
D2	-192	-0.71	0.479
D3	-476	-1.74	0.085
D4	494	1.79	0.076
γ	47.7	2.42	0.018
π_1	-0.042	-2.39	0.019
π_2	0.1	-2.12	0.037
π_3	-0.023	-0.27	0.789
π_4	0.268	-3.06	0.003

c) Dependent variable is detrended nominal GDP

Variables	Coeff	t-stat	Prob.
Const	28	0.14	0.889
D2	-192	-0.71	0.479
D3	-476	-1.74	0.085
D4	494	1.79	0.076
γ	0.589	0.29	0.769
π_1	-0.042	-2.39	0.019
π_2	0.1	-2.12	0.037
π_3	-0.023	-0.27	0.789
π_4	0.268	-3.06	0.003

Note: *For a):* $Ho: \pi_3 = \pi_4 = 0$, F stat= 10.2 df(2,82)

For b): $Ho: \pi_3 = \pi_4 = 0$, F stat= 4.75 df(2,82)

For c): $Ho: \pi_3 = \pi_4 = 0$, F stat= 4.75 df(2,82)

APPENDIX 6.3 ESTIMATION OF NEUTRALITY AND SUPERNEUTRALITY BIVARIATE VAR MODELS

Table A6.3.1 Selecting the order of the bivariate model:
Money (DM1 vs real output (DGDPR)

Lag Order	AIC	SBC	LR test	Adjusted LR test
12	-1268.4	-1329.7	------	------
11	-1269.5	-1326.0	CHSQ(4)= 10.2696[.036]	7.2842[.122]
10	-1267.1	-1318.6	CHSQ(8)= 13.3719[.100]	9.4847[.303]
9	-1263.6	-1310.2	CHSQ(12)= 14.4487[.273]	10.2485[.594]
8	-1261.8	-1303.5	CHSQ(16)= 18.8281[.278]	13.3548[.647]
7	-1265.5	-1302.3	CHSQ(20)= 34.1345[.025]	24.2117[.233]
6	-1268.8	-1300.7	CHSQ(24)= 48.9081[.002]	34.6906[.073]
5	-1265.8	-1292.8	CHSQ(28)= 50.9007[.005]	36.1040[.140]
4	-1262.5	-1284.6	CHSQ(32)= 52.2949[.013]	37.0929[.246]
3	-1292.0	-1309.2	CHSQ(36)= 119.2897[.000]	84.6125[.000]
2	-1325.8	-1338.1	CHSQ(40)= 194.7978[.000]	138.1705[.000]
1	-1333.0	-1340.4	CHSQ(44)= 217.2675[.000]	154.1084[.000]
0	-1341.0	-1343.5	CHSQ(48)= 241.2158[.000]	171.0949[.000]

Note: AIC= Akaike Information Criterion SBC=Schwarz Bayesian Criterion

Table A6.3.2 Cointegration test results
(of GDPR and M1)
(with unrestricted intercepts and no trends; VAR=5)

(i) Maximal Eigenvalue test

Null	Alternative	Statistic	95% Crit. Value	90% Crit. Value
r = 0	r = 1	14.5522	14.8800	12.9800
r<= 1	r = 2	1.0677	8.0700	6.5000

(ii) Trace test

Null	Alternative	Statistic	95% Crit. Value	90% Crit. Value
r = 0	r>= 1	15.6199	17.8600	15.7500
r<= 1	r = 2	1.0677	8.0700	6.5000

(iii) Using Model Selection Criteria

Rank	Maximized LL	AIC	SBC	HQC
r = 0	-1335.6	-1359.6	-1390.2	-1372.0
r = 1	-1328.4	-1355.4	-1389.7	-1369.2
r = 2	-1327.8	-1355.8	-1391.4	-1370.2

Notes: HQC = Hannan-Quinn Criterion (AIC and SBC defined in A6.3.1)
Eigenvalues in descending order: 0.14342, 0.011294

Table A6.3.3 OLS estimation of real output (DGDPR) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPR(-1)	-.09318	.10815	-.86161[.391]
DGDPR(-2)	-.14953	.11041	-1.35430[.179]
DGDPR(-3)	.03859	.11031	.34984[.727]
DGDPR(-4)	.22428	.11090	2.02240[.046]
DM1(-1)	-.00397	.09471	-.04197[.967]
DM1(-2)	.06679	.09301	.71810[.475]
DM1(-3)	.12012	.09313	1.28970[.201]
DM1(-4)	.01042	.09539	.10928[.913]
CONST	1048.70000	175.65160	5.97010[.000]
S1	-1616.10000	285.81070	-5.65450[.000]
S2	-1129.00000	270.66700	-4.17100[.000]
S3	-1096.60000	277.14240	-3.95670[.000]

R-Squared = .89700 R-Bar-Squared= .88318
S.E. of Regression= 300.3573 F(11, 82)= 64.9198[.000]
Mean of Dependent Variable= 119.3511 S.D= 878.7908
Residual Sum of Squares=7397592 Equation Log-likelihood= -663.2286
AIC= -675.2286 SBC= -690.4884
DW-statistic= 2.0015 System Log-likelihood= -1335.6

Table A6.3.4 Real output (DGDPR) equation diagnostic tests

* Test Statistics *	LM Version *	F Version
* A:Serial Correlation	* CHSQ(4) = 3.0087[.556]	*F(4,78)= .64478[.632]
* B:Functional Form	*CHSQ(1) = 2.8881[.089]	*F(1,81)= 2.5676[.113]
* C:Normality	*CHSQ(2) = .4195[.811]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1) = 1.9136[.167]	*F(1,92)= 1.9118[.170]

A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

Table A6.3.5 OLS estimation money (DM1) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPR(-1)	.12593	.12088	1.0417[.301]
DGDPR(-2)	-.08974	.12341	-.7271[.469]
DGDPR(-3)	-.36160	.12329	-2.9329[.004]
DGDPR(-4)	.12254	.12395	.9885[.326]
DM1(-1)	-.04231	.10586	-.3997[.690]
DM1(-2)	.10935	.10397	1.0518[.296]
DM1(-3)	-.03359	.10410	-.3227[.748]
DM1(-4)	.28050	.10662	2.6308[.010]
CONST	-154.53390	196.32690	-.7871[.433]
S1	112.28470	319.45250	.3514[.726]
S2	514.83980	302.52630	1.7018[.093]
S3	562.89760	309.76390	1.8172[.073]

R-Squared= .43904 R-Bar-Squared= .36379
S.E. of Regression= 335.7114 F(11, 82)= 5.8343[.000]
Mean of Dependent Variable = 173.4681 S.D= 420.8868
Residual Sum of Squares= 9241574 Equation Log-likelihood= -673.6888
AIC= -685.6888 SBC= -700.9486
DW-statistic= 2.0212 System Log-likelihood= -1335.6

Table A6.3.6 Money (DM1) equation diagnostic tests

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(4)= 2.9772[.562]	*F(4,78)= .63782[.637]
* B:Functional Form	*CHSQ(1)= .0168[.897]	*F(1,81)= .01450[.904]
* C:Normality	*CHSQ(2)=19.7597[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .5741[.449]	*F(1,92)= .56542[.454]

Table A6.3.7 Impulse and cumulative responses:
Money (DM1) vs real output (DGDPR)

	IMPULSE RESPONSES					
	(a) to money shock			*(b) to output shock*		
	DGDPR	DM1	IRD	DGDPR	DM1	IRD
1	49.194	335.708	0.070	300.000	55.000	0.383
2	-5.920	-8.007	0.354	-28.200	35.500	-2.628
3	15.666	31.880	0.235	-38.700	-26.000	1.403
4	40.973	-28.786	-0.682	28.450	-107.800	-7.911
5	9.421	111.063	0.041	72.900	70.000	2.005
6	-6.344	-20.043	0.152	-29.100	13.240	-0.950
7	8.650	8.354	0.496	-24.400	-21.800	1.865
8	21.363	-11.073	-0.924	24.100	-53.600	-4.644
9	-2.063	38.751	-0.025	17.720	43.800	5.161
10	-4.188	-14.828	0.135	-18.900	2.050	-0.226
11	4.854	0.549	4.235	-9.200	-15.290	3.470
12	8.410	-1.692	-2.381	14.660	-18.500	-2.635
13	-3.469	13.333	-0.125	3.000	23.000	16.007
14	-1.940	-8.387	0.111	-10.200	1.854	-0.380
15	2.838	-0.356	-3.818	-1.800	-9.058	10.507
20	0.722	1.148	0.301	3.460	0.020	0.012
25	-0.644	0.168	-1.836	-0.960	1.813	-3.943
30	0.129	-0.355	-0.174	-0.210	-0.741	7.367
35	0.051	0.114	0.214	0.200	-0.004	-0.042
40	-0.035	0.010	-1.676	-0.030	0.105	-7.308
	CUMULATIVE RESPONSES					
	(c) to money shock			*(d) to output shock*		
	DGDPR	DM1	LRD	DGDPR	DM1	LRD
1	49	336	0.069	300	55.00	0.383
2	43	327	0.063	272	90.00	0.691
3	59	360	0.078	233	64.00	0.573
4	100	331	0.145	262	-43.00	-0.343
5	109	442	0.118	334	27.00	0.169
6	103	422	0.117	306	40.00	0.273
7	112	430	0.125	281	18.00	0.134
8	133	419	0.152	305	-35.00	-0.240
9	131	458	0.137	323	8.00	0.052
10	127	443	0.137	304	10.00	0.069
11	132	443	0.143	295	-5.00	-0.035
12	140	442	0.152	309	-23.00	-0.155
13	137	455	0.143	313	-0.46	-0.003
14	135	447	0.145	302	-2.32	-0.016
15	137	446	0.147	300	-11.40	-0.079
20	140	449	0.148	306	-12.00	-0.082
25	138	449	0.149	305	-8.60	-0.059
30	139	448	0.149	304	-10.10	-0.069
35	139	448	0.149	304	-10.10	-0.069
40	139	448	0.149	305	-10.00	-0.068

Notes: The responses are in original units, but the IRD and LRD values are in standardized units.
IRD = Impulse responses derivative
LRD = Long run derivative (Fish and Seater LRD test statistic)

Table A6.3.8 Selecting the order of the bivariate model:
Money (DM1) vs nominal output (DGDPN)

Lag order	AIC	SBC	LR test	Adjusted LR test
12	-1307.6	-1378.8	------	------
11	-1305.6	-1371.9	CHSQ(4)= 3.9630[.411]	2.6266[.622]
10	-1308.2	-1369.6	CHSQ(8)= 17.2201[.028]	11.4133[.179]
9	-1305.7	-1362.1	CHSQ(12)= 20.0969[.065]	13.3201[.346]
8	-1304.8	-1356.3	CHSQ(16)= 26.3219[.050]	17.4459[.357]
7	-1303.4	-1350.1	CHSQ(20)= 31.6166[.048]	20.9552[.400]
6	-1304.4	-1346.1	CHSQ(24)= 41.5797[.014]	27.5587[.279]
5	-1306.5	-1343.3	CHSQ(28)= 53.7594[.002]	35.6313[.152]
4	-1305.1	-1337.0	CHSQ(32)= 59.0034[.003]	39.1069[.181]
3	-1309.6	-1336.6	CHSQ(36)= 76.0401[.000]	50.3987[.056]
2	-1316.5	-1338.6	CHSQ(40)= 97.7787[.000]	64.8068[.008]
1	-1314.2	-1331.4	CHSQ(44)= 101.1762[.000]	67.0586[.014]
0	-1331.7	-1343.9	CHSQ(48)= 144.0861[.000]	95.4989[.000]

Table A6.3.9 OLS estimation of nominal output (DGDPN) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPN(-1)	-.72838	.10928	-6.6652[.000]
DGDPN(-2)	-.42680	.13104	-3.2570[.002]
DGDPN(-3)	-.10233	.12519	-.8174[.416]
DGDPN(-4)	.56394	.12483	4.5178[.000]
DGDPN(-5)	.42517	.13256	3.2073[.002]
DGDPN(-6)	.33623	.11203	3.0013[.004]
DM1(-1)	.19193	.17453	1.0997[.275]
DM1(-2)	.15773	.17919	.8802[.382]
DM1(-3)	.17813	.17531	1.0161[.313]
DM1(-4)	.06023	.17794	.3385[.736]
DM1(-5)	-.14030	.20237	-.6932[.490]
DM1(-6)	-.27780	.20356	-1.3647[.176]
CONST	836.84750	236.08940	3.5446[.001]
T	-.43433	2.44900	-.1773[.860]
S1	-572.27210	303.14070	-1.8878[.063]
S2	-747.50370	295.49240	-2.5297[.014]
S3	-919.29110	280.36710	-3.2789[.002]

R-Squared = .88240 R-Bar-Squared = .85731
S.E. of Regression= 514.2807 F(16, 75)= 35.1723[.000]
Mean of Dependent Variable= 288.1304 S.D= 1361.5
Residual Sum of Squares= 1.98E+07 Equation Log-likelihood= -695.4793
AIC= -712.4793 SBC= -733.9145
DW-statistic = 1.8468 System Log-likelihood = -1353.9

Table A6.3.10 Nominal output (DGDPN) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 7.1516[.128]	*F(4,71)= 1.4961[.213]
* B:Functional Form	*CHSQ(1)=12.7370[.000]	*F(1,74)=11.8913[.001]
* C:Normality	*CHSQ(2)= 5.5495[.062]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 1.1002[.294]	*F(1,90)= 1.0893[.299]

Table A6.3.11 OLS estimation of money (DM1) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPN(-1)	.08003	.07384	1.0838[.282]
DGDPN(-2)	.04561	.08854	.51511[.608]
DGDPN(-3)	-.7364E-3	.08459	-.0087046[.993]
DGDPN(-4)	.14754	.08435	1.7491[.084]
DGDPN(-5)	.05873	.08957	.65573[.514]
DGDPN(-6)	-.05122	.07570	-.67663[.501]
DM1(-1)	-.10385	.11794	-.88057[.381]
DM1(-2)	-.00638	.12108	-.052730[.958]
DM1(-3)	-.15455	.11846	-1.3046[.196]
DM1(-4)	.19723	.12024	1.6403[.105]
DM1(-5)	-.13941	.13675	-1.0194[.311]
DM1(-6)	-.06826	.13755	-.49628[.621]
CONST	13.28950	159.53600	.083301[.934]
T	3.79290	1.65490	2.2919[.025]
S1	-220.34740	204.84540	-1.0757[.286]
S2	-34.05520	199.67710	-.17055[.865]
S3	-67.31320	189.45630	-.35530[.723]

R-Squared= .44549 R-Bar-Squared= .32719
S.E. of Regression= 347.5220 F(16, 75)= 3.7659[.000]
Mean of Dependent Variable= 175.0435 S.D= 423.6781
Residual Sum of Squares= 9057865 Equation Log-likelihood= -659.4207
AIC= -676.4207 SBC= -697.8559
DW-statistic= 1.9310 System Log-likelihood= -1353.9

Table A6.3.12 Money (DM1) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 6.5544[.161]	*F(4,71)= 1.3616[.256]
* B:Functional Form	*CHSQ(1)= .2540[.614]	*F(1,74)= .2049[.652]
* C:Normality	*CHSQ(2)=10.5794[.005]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 1.7258[.189]	*F(1,90)= 1.7206[.193]

Table A6.3.13 Impulse and cumulative responses:
Money (DM1) vs nominal output (DGDPN)

	IMPULSE RESPONSES					
	(c) to money shock			(d) to output shock		
	DGDPN	DM1	IRD	DGDPN	DM1	IRD
1	119.9	417.5	0.08	499.4	100.2	0.69
2	-20.3	-13.2	0.45	-360.4	19.4	-0.19
3	9.3	15.8	0.17	143.2	-5.0	-0.12
4	52.2	-79.4	-0.19	64.7	-46.2	-2.46
5	16.5	95.2	0.05	120.2	152.6	4.37
6	-64.7	-37.1	0.51	-83.1	-49.9	2.07
7	1.9	-2.9	-0.19	72.3	-21.8	-1.04
8	46.2	-17.7	-0.76	-13.8	7.5	-1.87
9	-2.7	40.2	-0.02	112.2	63.9	1.96
10	-26.6	-27.3	0.28	-68.1	-26.8	1.36
11	-5.4	-5.2	0.30	37.2	0.7	0.06
12	27.1	4.7	1.68	22.4	-6.0	-0.92
13	-2.1	17.7	-0.03	35.3	40.0	3.91
14	-13.3	-14.1	0.27	-32.5	-15.7	1.65
15	-1.8	-5.2	0.10	32.3	-2.4	-0.26
20	8.0	4.4	0.52	6.9	2.2	1.11
25	-2.9	0.8	-1.12	3.8	4.8	4.33
30	-0.3	-1.1	0.08	-1.5	-2.0	4.50
35	0.4	0.0	8.05	2.0	0.6	1.08
40	0.2	0.3	0.17	0.3	0.3	3.60

	CUMULATIVE RESPONSES					
	(c) to money shock			(d) to output shock		
	DGDPN	DM1	LRD	DGDPN	DM1	LRD
1	120	417	0.08	499	100	0.69
2	100	404	0.07	139	120	2.96
3	109	420	0.08	282	115	1.40
4	161	341	0.14	347	68	0.68
5	178	436	0.12	467	221	1.63
6	113	399	0.08	384	171	1.53
7	115	396	0.08	456	149	1.13
8	161	378	0.12	443	157	1.22
9	158	418	0.11	555	221	1.37
10	132	391	0.10	487	194	1.37
11	126	386	0.10	524	195	1.28
12	153	391	0.11	546	189	1.19
13	151	408	0.11	582	229	1.35
14	138	394	0.10	549	213	1.33
15	136	389	0.10	581	210	1.25
20	150	396	0.11	613	226	1.27
25	146	398	0.11	632	238	1.29
30	146	396	0.11	637	237	1.28
35	146	396	0.11	644	239	1.28
40	147	397	0.11	646	240	1.28

Table A6.3.14 Selecting the Order of the VAR Model
Money (DM3) vs realoutput (DGDPR)

Lag Order	AIC	SBC	LR test	Adjusted LR test
12	-1403.6	-1464.9	------	------
11	-1406.1	-1462.6	CHSQ(4)= 13.1943[.010]	9.3587[.053]
10	-1403.1	-1454.7	CHSQ(8)= 15.1708[.056]	10.7606[.216]
9	-1400.5	-1447.2	CHSQ(12)= 17.9797[.116]	12.7531[.387]
8	-1398.8	-1440.5	CHSQ(16)= 22.5290[.127]	15.9799[.454]
7	-1400.2	-1437.0	CHSQ(20)= 33.3114[.031]	23.6279[.259]
6	-1403.2	-1435.1	CHSQ(24)= 47.3682[.003]	33.5984[.092]
5	-1403.0	-1430.0	CHSQ(28)= 54.9570[.002]	38.9811[.081]
4	-1402.0	-1424.1	CHSQ(32)= 60.8780[.002]	43.1809[.090]
3	-1429.1	-1446.3	CHSQ(36)= 123.1357[.000]	87.3404[.000]
2	-1460.8	-1473.1	CHSQ(40)= 194.5904[.000]	138.0235[.000]
1	-1473.9	-1481.2	CHSQ(44)= 228.6487[.000]	162.1811[.000]
0	-1476.5	-1479.0	CHSQ(48)= 241.9480[.000]	171.6143[.000]

Table A6.3.15 Cointegration test results
(of GDPR and M3)
(with unrestricted intercepts and restricted trends in the VAR, order= 5)

(i) Maximal Eigenvalue test

Null	Alternative	Statistic	95% Crit.Value	90% Crit.Value
r = 0	r = 1	15.0931	19.2200	17.1800
r<= 1	r = 2	4.4331	12.3900	10.5500

(ii) Trace test

Null	Alternative	Statistic	95% Crit. Value	90% Crit.Value
r = 0	r>= 1	19.5262	25.7700	23.0800
r<= 1	r = 2	4.4331	12.3900	10.5500

(iii) Using Model Selection Criteria

Rank	Maximized LL	AIC	SBC	HQC
r = 0	-1490.2	-1514.2	-1544.8	-1526.6
r = 1	-1482.7	-1510.7	-1546.3	-1525.1
r = 2	-1480.5	-1510.5	-1548.6	-1525.9

Note: List of eigenvalues in descending order: 0.14834, 0.046066,

Table A6.3.16 OLS estimation of real output (DGDPR) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPR(-1)	-.06216	.11189	-.5556[.580]
DGDPR(-2)	-.16605	.11067	-1.5004[.137]
DGDPR(-3)	.09030	.11010	.8201[.415]
DGDPR(-4)	.24629	.10805	2.2794[.025]
DGDPR(-5)	-.04752	.10710	-.4437[.658]
DM3(-1)	.02189	.01958	1.1179[.267]
DM3(-2)	.02900	.02051	1.4143[.161]
DM3(-3)	-.03482	.02346	-1.4844[.142]
DM3(-4)	.01747	.02380	.7337[.465]
DM3(-5)	-.00208	.02507	-.0832[.934]
CONST	983.86830	178.00540	5.5272[.000]
S1	-1499.30000	296.19760	-5.0617[.000]
S2	-1079.40000	280.88350	-3.8430[.000]
S3	-1062.70000	273.05670	-3.8920[.000]

R-Squared = .90099 R-Bar-Squared= .88469
S.E. of Regression = 296.7340 F(13, 79)= 55.2975[.000]
Mean of Dependent Variable = 105.9570 S.D= 873.8538
Residual Sum of Squares = 6956036 Equation Log-likelihood= -653.8085
AIC= -667.8085 SBC= -685.5367
DW-statistic = 2.0110 System Log-likelihood= -1471.2

Table A6.3.17 Real output (DGDPR) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 4.4994[.343]	*F(4,75)= .9532[.438]
* B:Functional Form	*CHSQ(1)= 5.1777[.023]	*F(1,78)=4.5986[.035]
C:Normality	*CHSQ(2)= .5757[.750]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .3663[.545]	*F(1,91)= .359[.550]

Table A6.3.18 OLS estimation of money (DM3) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DGDPR(-1)	-.08459	.64977	-.13019[.897]
DGDPR(-2)	.51032	.64269	.79403[.430]
DGDPR(-3)	.26066	.63941	.40765[.685]
DGDPR(-4)	.18924	.62750	.30159[.764]
DGDPR(-5)	.07022	.62198	.11291[.910]
DM3(-1)	-.11102	.11372	-.97634[.332]
DM3(-2)	.34657	.11912	2.90950[.005]
DM3(-3)	.03515	.13624	.25799[.797]
DM3(-4)	-.21555	.13827	-1.55890[.123]
DM3(-5)	.34374	.14564	2.36010[.021]
CONST	1130.80000	1033.80000	1.09390[.277]
S1	-1201.60000	1720.20000	-.69851[.487]
S2	-510.18000	1631.20000	-.31276[.755]
S3	-140.76990	1585.80000	-.08877[.929]

R-Squared = .24241 R-Bar-Squared = .11774
S.E. of Regression = 1723.3 F(13, 79)= 1.9444[.037]
Mean of Dependent Variable= 1217.4 S.D= 1834.7
Residual Sum of Squares= 2.35E+08 Equation Log-likelihood=-817.4091
AIC= -831.4091 SBC= -849.1373
DW-statistic = 2.0822 System Log-likelihood = -1471.2

Table A6.3.19 Money (DM3) equation diagnostic tests

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(4)= 8.1607[.086]	*F(4,75)= 1.8036[.137]
* B:Functional Form	*CHSQ(1)=12.1753[.000]	*F(1,78)= 11.7498[.001]
* C:Normality	*CHSQ(2)=36.1464[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 1.8791[.170]	*F(1,91)= 1.8766[.174]

Table A6.3.20 Impulse and cumulative responses :
Money (DM3) vs real output (DGDPR)

	IMPULSE RESPONSES					
	(a) to money shock			*(b) to output shock*		
	DGDPR	DM3	IRD	DGDPR	DM3	IRD
1	3.96	1723.29	0.00	296.69	23.00	0.04
2	37.48	-191.66	-0.41	-17.94	-27.72	0.74
3	42.79	617.35	0.15	-48.05	163.89	-1.62
4	-60.59	-57.86	2.20	34.72	45.24	0.62
5	54.43	-120.34	-0.95	84.39	70.03	0.40
6	-13.16	631.72	-0.04	-37.24	43.01	-0.55
7	18.61	-288.99	-0.14	-15.23	21.10	-0.66
8	2.88	468.87	0.01	25.30	69.11	1.30
9	-10.27	-112.05	0.19	18.49	0.45	0.01
10	28.51	-4.25	-14.08	-18.01	45.67	-1.21
11	-20.63	253.27	-0.17	-2.76	19.80	-3.41
12	13.56	-218.47	-0.13	14.69	5.60	0.18
13	2.27	291.22	0.02	0.24	29.44	57.25
14	-5.37	-130.71	0.09	-7.10	-5.69	0.38
15	12.37	54.93	0.47	2.69	25.23	4.47
20	6.54	66.08	0.21	1.28	13.12	4.87
25	2.44	57.16	0.09	-0.70	7.53	-5.15
30	0.43	42.49	0.02	-0.04	4.02	-43.22
35	-0.32	28.45	-0.02	-0.11	1.99	-8.81
40	-0.54	17.44	-0.07	-0.11	0.88	-3.96

	CUMULATIVE RESPONSES					
	(a) to money shock			*(b) to output shock*		
	DGDPR	DM3	LRD	DGDPR	DM3	LRD
1	4.0	1723	0.005	297	23	0.04
2	41.4	1532	0.057	279	-5	-0.01
3	84.2	2149	0.082	231	159	0.33
4	23.6	2091	0.024	265	204	0.37
5	78.1	1971	0.083	350	274	0.37
6	64.9	2602	0.052	313	317	0.48
7	83.5	2314	0.076	297	339	0.54
8	86.4	2782	0.065	323	408	0.60
9	76.1	2670	0.060	341	408	0.57
10	104.6	2666	0.082	323	454	0.67
11	84.0	2919	0.060	320	474	0.70
12	97.6	2701	0.076	335	479	0.68
13	99.8	2992	0.070	335	509	0.72
14	94.5	2861	0.069	328	503	0.73
15	106.8	2916	0.077	331	528	0.76
20	107.5	3007	0.075	335	553	0.79
25	106.9	3037	0.074	334	562	0.80
30	106.2	3045	0.073	335	565	0.80
35	105.8	3044	0.073	335	566	0.80
40	105.7	3041	0.073	335	565	0.80

Table A6.3.21 Selecting the order of the VAR:
Money (DM1) vs Price (DCPI)

Lag Order	AIC	SBC	LR test	Adjusted LR test
12	-941.1478	-1002.5	------	------
11	-939.4140	-995.8640	CHSQ(4)= 4.5323[.339]	3.2148[.523]
10	-938.0202	-989.5615	CHSQ(8)= 9.7448[.283]	6.9120[.546]
9	-935.1845	-981.8171	CHSQ(12)= 12.0735[.440]	8.5637[.740]
8	-934.9650	-976.6889	CHSQ(16)= 19.6345[.237]	13.9268[.604]
7	-935.8314	-972.6466	CHSQ(20)= 29.3671[.081]	20.8302[.407]
6	-935.2591	-967.1656	CHSQ(24)= 36.2225[.052]	25.6927[.369]
5	-932.6841	-959.6819	CHSQ(28)= 39.0726[.080]	27.7143[.480]
4	-931.0066	-953.0957	CHSQ(32)= 43.7176[.081]	31.0090[.517]
3	-938.4730	-955.6534	CHSQ(36)= 66.6504[.001]	47.2753[.099]
2	-935.7552	-948.0269	CHSQ(40)= 69.2147[.003]	49.0942[.153]
1	-934.9313	-942.2944	CHSQ(44)= 75.5671[.002]	53.5999[.152]
0	-948.9045	-951.3589	CHSQ(48)= 111.5134[.000]	79.0967[.003]

Table A6.3.22 Cointegration test results:
(of CPI and money M1)
(with unrestricted intercepts and no trends, VAR=5)

(i) Maximal Eigenvalue test				
Null	Alternative	Statistic	95% Crit. Value	90% Crit. Value
r = 0	r = 1	11.8671	14.8800	12.9800
r<= 1	r = 2	.0570	8.0700	6.5000
(ii) Trace statistic test				
Null	Alternative	Statistic	95% Crit. Value	90% Crit.Value
r = 0	r>= 1	11.9242	17.8600	15.7500
r<= 1	r = 2	.0571	8.0700	6.5000
(iii) Using Model Selection Criteria				
Rank	Maximized LL	AIC	SBC	HQC
r = 0	-990.7558	-1008.8	-1031.6	-1018.0
r = 1	-984.8223	-1005.8	-1032.5	-1016.6
r = 2	-984.7938	-1006.8	-1034.8	-1018.1

Note: List of eigenvalues in descending order: 0.11860 0.0006068

Table A6.3.23 OLS estimation of money (DM1) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DM1(-1)	-.0966	.11260	-.8584[.393]
DM1(-2)	-.1289	.11323	-1.1385[.258]
DM1(-3)	-.1077	.10867	-.9917[.324]
DM1(-4)	.2625	.11204	2.3437[.022]
DM1(-5)	-.2147	.13638	-1.5746[.119]
DCPI(-1)	1.5594	6.13610	.2541[.800]
DCPI(-2)	-1.1906	6.39720	-.1861[.853]
DCPI(-3)	8.8482	6.51090	1.3590[.178]
DCPI(-4)	-4.7038	6.49480	-.7242[.471]
DCPI(-5)	9.4028	6.08400	1.5455[.126]
CONST	33.0364	163.78630	.2017[.841]
T	5.4402	1.90560	2.8549[.006]
S1	-272.7504	132.84780	-2.0531[.043]
S2	-310.0653	128.20770	-2.4185[.018]
S3	-337.5280	124.72450	-2.7062[.008]

R-Squared = .43557 R-Bar-Squared = .33426
S.E. of Regression= 344.9250 F(14,78)= 4.2995[.000]
Mean of Dependent Variable= 171.5161 S.D.= 422.7400
Residual Sum of Squares = 9279912 Equation Log-likelihood= -667.2118
AIC = -682.2118 SBC = -701.2063
DW-statistic = 1.9623 System Log-likelihood = -962.7010

Table A6.3.24 Money (DM1) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 5.4814[.241]	* F(4,74)= 1.1587[.336]
* B:Functional Form	*CHSQ(1)= .0101[.920]	*F(1,77)= .0083[.927]
* C:Normality	*CHSQ(2)=20.2349[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .6498[.420]	*F(1,91)= .6403[.426]

Table A6.3.25 OLS estimation of price (DCPI) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DM1(-1)	.0018	.0020	.9002[.371]
DM1(-2)	.0025	.0020	1.2445[.217]
DM1(-3)	.7422E-3	.0019	.3711[.712]
DM1(-4)	.0037	.0020	1.8074[.075]
DM1(-5)	.0011	.0025	.4597[.647]
DCPI(-1)	.3667	.1129	3.2476[.002]
DCPI(-2)	.2098	.1177	1.7820[.079]
DCPI(-3)	.0024	.1198	.0205[.984]
DCPI(-4)	-.1235	.1195	-1.0335[.305]
DCPI(-5)	.0385	.1119	.3446[.731]
CONST	8.0381	3.0142	2.6667[.009]
T	-.0979	.0350	-2.7930[.007]
S1	-3.1534	2.4449	-1.2898[.201]
S2	1.1576	2.3595	.4906[.625]
S3	2.0781	2.2954	.9053[.368]

R-Squared = .46501 R-Bar-Squared = .36899
S.E. of Regression= 6.3478 F(14, 78)= 4.8427[.000]
Mean of Dependent Variable = 8.8925 S.D = 7.9911
Residual Sum of Squares = 3143.0 Equation Log-likelihood = -295.6568
AIC = -310.6568 SBC = -329.6513
DW-statistic = 2.0228 System Log-likelihood = -962.7010

Table A6.3.26 Price (DCPI) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 3.8640[.425]	*F(4,74)= .8019[.528]
* B:Functional Form	*CHSQ(1)= .0430[.836]	*F(1,77)= .0356[.851]
* C:Normality	*CHSQ(2)=1065.80[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 5.7847[.016]	*F(1,91)=6.0357[.016]

Table A6.3.27 Impulse and cumulative responses:
Price (DCPI) vs money (DM1)

	IMPULSE RESPONSES					
	(a) to monetary shock			*(b) to price shock*		
	DCPI	DM1	IRD	DCPI	DM1	IRD
1	-0.381	344.93	-0.058	6.348	-20.692	-0.062
2	0.504	-33.93	-0.785	2.289	11.899	0.098
3	0.936	-39.95	-1.240	2.140	-2.470	-0.022
4	0.542	-31.45	-0.911	1.292	57.713	0.845
5	1.541	108.40	0.752	0.177	-22.111	-2.360
6	0.967	-81.01	-0.631	0.430	69.123	3.036
7	0.502	-1.16	-22.938	0.141	10.095	1.352
8	0.065	18.71	0.183	0.459	23.502	0.967
9	0.301	48.19	0.331	0.333	-13.554	-0.770
10	0.026	-36.72	-0.038	0.448	20.952	0.885
11	0.021	19.40	0.057	0.373	-7.254	-0.368
12	0.070	9.91	0.376	0.310	5.622	0.343
13	0.238	8.64	1.459	0.154	-3.717	-0.457
14	0.086	-21.01	-0.215	0.145	13.022	1.703
15	0.100	13.45	0.395	0.073	-2.548	-0.658
20	0.023	-1.45	-0.843	0.053	2.280	0.807
25	0.013	0.23	2.982	0.010	-0.133	-0.247
30	0.001	0.09	0.504	0.007	0.314	0.807
35	0.003	0.12	1.240	0.001	-0.074	-1.265
40	0.000	-0.09	0.105	0.001	0.078	1.442
	CUMULATIVE RESPONSES					
	(c) to monetary shock			*(d) to price shock*		
	DCPI	DM1	LRD	DCPI	DM1	LRD
1	-0.381	344.93	-0.058	6.348	-20.692	-0.062
2	0.123	310.99	0.021	8.637	-8.793	-0.019
3	1.059	271.05	0.207	10.777	-11.264	-0.020
4	1.601	239.60	0.353	12.069	46.449	0.073
5	3.142	347.99	0.478	12.246	24.338	0.038
6	4.109	266.98	0.814	12.676	93.461	0.139
7	4.610	265.83	0.918	12.817	103.556	0.153
8	4.675	284.54	0.869	13.277	127.058	0.181
9	4.976	332.73	0.791	13.610	113.504	0.158
10	5.002	296.01	0.894	14.057	134.457	0.181
11	5.023	315.41	0.843	14.430	127.203	0.167
12	5.094	325.32	0.828	14.740	132.825	0.170
13	5.332	333.96	0.845	14.894	129.108	0.164
14	5.417	312.95	0.916	15.039	142.129	0.179
15	5.518	326.39	0.894	15.112	139.581	0.175
20	5.735	329.91	0.920	15.404	149.367	0.183
25	5.818	330.50	0.931	15.522	151.072	0.184
30	5.839	331.36	0.932	15.565	152.272	0.185
35	5.853	331.71	0.933	15.579	152.399	0.185
40	5.855	331.61	0.934	15.585	152.622	0.185

Table A6.3.28 Selecting the order of the bivariate model:
Interest rate (DINT) vs inflation rate (DINF)

Lag Order	AIC	SBC	LR test	Adjusted LR test
12	-243.6793	-305.0380	------	------
11	-241.7429	-298.1929	CHSQ(4)= 4.1272[.389]	2.9274[.570]
10	-242.2486	-293.7899	CHSQ(8)= 13.1385[.107]	9.3191[.316]
9	-241.4669	-288.0995	CHSQ(12)= 19.5751[.076]	13.8847[.308]
8	-239.1621	-280.8860	CHSQ(16)= 22.9654[.115]	16.2894[.433]
7	-236.0771	-272.8923	CHSQ(20)= 24.7955[.209]	17.5875[.615]
6	-233.5270	-265.4335	CHSQ(24)= 27.6953[.273]	19.6444[.717]
5	-231.1102	-258.1080	CHSQ(28)= 30.8617[.323]	21.8903[.786]
4	-230.7895	-252.8787	CHSQ(32)= 38.2204[.208]	27.1098[.713]
3	-232.9963	-250.1767	CHSQ(36)= 50.6339[.054]	35.9147[.473]
2	-233.8329	-246.1046	CHSQ(40)= 60.3071[.021]	42.7760[.353]
1	-234.4071	-241.7701	CHSQ(44)= 69.4555[.009]	49.2649[.271]
0	-246.8119	-249.2662	CHSQ(48)= 102.2651[.000]	72.5369[.013]

Table A6.3.29 OLS estimation of interest rate (DINT) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINT(-1)	.42089	.10330	4.0744[.000]
DINT(-2)	-.21577	.11320	-1.9061[.060]
DINT(-3)	.03346	.11241	.29770[.767]
DINT(-4)	-.07231	.10317	-.70087[.485]
DINF(-1)	.22405	.071431	3.1366[.002]
DINF(-2)	.21908	.076811	2.8522[.005]
DINF(-3)	.15773	.077977	2.0228[.046]
DINF(-4)	.20518	.072020	2.8489[.006]
CONST	-.01536	.072784	-.21103[.833]

R-Squared = .35940 R-Bar-Squared = .29910
S.E. of Regression= .70214 F(8, 85)= 5.9609[.000]
Mean of Dependent Variable= -.047447 S.D= .83868
Residual Sum of Squares= 41.9046 Equation Log-likelihood= -95.4090
AIC= -104.4090 SBC= -115.8538
DW-statistic= 2.0793 System Log-likelihood= -228.5864

Table A6.3.30 Interest rate (DINT) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 7.4802[.113]	*F(4,81)= 1.75070[.147]
* B:Functional Form	*CHSQ(1)= .0012451[.972]	*F(1,84)= .0011[.973]
* C:Normality	*CHSQ(2)= 26.4437[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .031009[.860]	*F(1,92)= .03036[.862]

Table A6.3.31 OLS estimation of inflation rate (DINF) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINT(-1)	-.09119	.15444	-.59053[.556]
DINT(-2)	.30474	.16924	1.8007[.075]
DINT(-3)	-.31585	.16805	-1.8794[.064]
DINT(-4)	-.18951	.15424	-1.2286[.223]
DINF(-1)	-.44010	.10679	-4.1212[.000]
DINF(-2)	-.12974	.11483	-1.1298[.262]
DINF(-3)	-.20697	.11658	-1.7754[.079]
DINF(-4)	-.13555	.10767	-1.2589[.212]
CONST	-.05319	.10881	-.48885[.626]

R-Squared= .24896 R-Bar-Squared= .17827
S.E. of Regression= 1.0497 F(8, 85)= 3.5220[.001]
Mean of Dependent Variable= -.021596 S.D= 1.1580
Residual Sum of Squares= 93.6578 Equation Log-likelihood = -133.2088
AIC= -142.2088 SBC= -153.6536
DW-statistic= 2.0412 System Log-likelihood= -228.5864

Table A6.3.32 Inflation rate (DINF) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
A:Serial Correlation	*CHSQ(4)= 2.6072[.626]	*F(4,81)= .57768[.680]
* B:Functional Form	*CHSQ(1)= 20.8668[.000]	*F(1,84)=23.9673[.000]
* C:Normality	*CHSQ(2)=304.1619[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 5.9380[.015]	*F(1,92)= 6.2036[.015]

Table A6.3.33 Impulse and cumulative responses:
Inflation rate (DINF) vs interest rate (DINT)

	IMPULSE RESPONSES					
	(a) to inflation rate shock			(b) to interst rate shock		
	DINT	DINF	IRD	DINT	DINF	IRD
1	0.0179	1.0500	0.02	0.7021	0.0268	0.03
2	0.2430	-0.4638	-0.72	0.3018	-0.0752	-0.18
3	0.2245	0.0508	6.11	-0.0355	0.2157	-4.39
4	0.1177	-0.1316	-1.24	-0.0206	-0.2174	7.65
5	0.1321	-0.0175	-10.45	-0.0494	-0.1576	2.31
6	-0.0998	-0.0158	8.70	-0.1038	0.0155	-0.11
7	-0.1005	-0.0008	167.30	-0.0521	0.0371	-0.52
8	-0.0583	-0.0613	1.31	-0.0574	0.0364	-0.46
9	-0.0357	0.0139	-3.54	-0.0265	0.0287	-0.79
10	-0.0123	0.0403	-0.42	0.0304	-0.0061	-0.15
11	0.0101	0.0210	0.67	0.0387	0.0036	0.07
12	0.0131	0.0086	2.09	0.0244	0.0133	0.39
13	0.0212	-0.0042	-6.94	0.0136	-0.0040	-0.21
14	0.0199	-0.0079	-3.48	0.0009	-0.0117	-9.86
15	0.0065	-0.0020	-4.48	-0.0052	-0.0086	1.19
20	-0.0019	0.0022	-1.18	0.0010	0.0012	0.95
25	0.0009	-0.0003	-4.49	-0.0008	-0.0001	0.08
30	-0.0003	0.0002	-2.36	0.0001	0.0000	0.07
35	0.0001	0.0000	-5.95	-0.0001	0.0000	-0.17
40	0.0000	0.0000	-4.58	0.0000	0.0000	-0.39

	CUMULATIVE RESPONSES					
	(c) to inflation rate shock			(d) to interest rate shock		
	DINT	DINF	LRD	DINT	DINF	LRD
1	0.018	1.0500	0.02	0.702	0.027	0.03
2	0.261	0.5863	0.62	1.004	-0.048	-0.03
3	0.485	0.6370	1.05	0.968	0.167	0.13
4	0.603	0.5054	1.65	0.948	-0.050	-0.04
5	0.735	0.4879	2.08	0.898	-0.208	-0.17
6	0.635	0.4721	1.86	0.795	-0.192	-0.18
7	0.535	0.4713	1.57	0.742	-0.155	-0.15
8	0.477	0.4099	1.61	0.685	-0.119	-0.13
9	0.441	0.4239	1.44	0.659	-0.090	-0.10
10	0.429	0.4642	1.28	0.689	-0.096	-0.10
11	0.439	0.4851	1.25	0.728	-0.092	-0.09
12	0.452	0.4937	1.26	0.752	-0.079	-0.08
13	0.473	0.4895	1.34	0.766	-0.083	-0.08
14	0.493	0.4816	1.41	0.766	-0.095	-0.09
15	0.499	0.4797	1.44	0.761	-0.103	-0.10
20	0.473	0.4734	1.38	0.740	-0.100	-0.10
25	0.476	0.4761	1.38	0.748	-0.100	-0.10
30	0.475	0.4753	1.38	0.745	-0.100	-0.10
35	0.476	0.4756	1.38	0.746	-0.100	-0.10
40	0.475	0.4755	1.38	0.746	-0.100	-0.10

Table A6.3.34 Selecting the order of the bivariate model:
Inflation rate (DINF) vs real output (DGDPR)

Lag order	AIC	SBC	LR test	Adjusted LR test
12	-751.1563	-819.8780	------	------
11	-748.4799	-812.2930	CHSQ(4)= 2.6473[.618]	1.7854[.775]
10	-750.8811	-809.7854	CHSQ(8)= 15.4496[.051]	10.4195[.237]
9	-747.8547	-801.8503	CHSQ(12)= 17.3968[.135]	11.7327[.467]
8	-744.3680	-793.4549	CHSQ(16)= 18.4234[.300]	12.4251[.714]
7	-746.0435	-790.2217	CHSQ(20)= 29.7744[.074]	20.0804[.453]
6	-742.9951	-782.2647	CHSQ(24)= 31.6776[.135]	21.3640[.617]
5	-742.2533	-776.6142	CHSQ(28)= 38.1940[.095]	25.7588[.586]
4	-741.0696	-770.5217	CHSQ(32)= 43.8266[.079]	29.5574[.591]
3	-750.5378	-775.0813	CHSQ(36)= 70.7631[.000]	47.7239[.091]
2	-747.3706	-767.0054	CHSQ(40)= 72.4287[.001]	48.8473[.159]
1	-748.2970	-763.0231	CHSQ(44)= 82.2815[.000]	55.4922[.115]
0	-754.4471	-764.2645	CHSQ(48)= 102.5817[.000]	69.1830[.024]

Table A6.3.35 OLS estimation of inflation rate (DINF) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINF(-1)	-.42541	.10664	-3.9891[.000]
DINF(-2)	-.15996	.11447	-1.3974[.166]
DINF(-3)	-.23738	.11282	-2.1040[.038]
DINF(-4)	-.15486	.099471	-1.5569[.123]
DGDPR(-1)	.9712E-3	.3500E-3	2.7747[.007]
DGDPR(-2)	.00105	.3715E-3	2.8341[.006]
DGDPR(-3)	.2134E-3	.3780E-3	.5646[.574]
DGDPR(-4)	.7621E-3	.3636E-3	2.0961[.039]
CONST	-.92913	.61051	-1.5219[.132]
S1	-.38148	.98435	-.3875[.699]
S2	.88619	.96281	.9204[.360]
S3	1.65810	.99212	1.6713[.098]

R-Squared = .36607 R-Bar-Squared = .28103
S.E. of Regression = .98187 F(11,82)= 4.3047[.000]
Mean of Dependent Variable= -.021596 S.D.= 1.1580
Residual Sum of Squares= 79.0538 Equation Log-likelihood= -125.2414
AIC = -137.2414 SBC = -152.5012
DW-statistic = 2.0257 System Log-likelihood = -780.6565

Table A6.3.36 Inflation rate (DINF) equation diagnostic tests

* Test Statistics	* LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= .3766[.984]	* F(4,78)= .0784[.989]
* B:Functional Form	*CHSQ(1)= 14.7111[.000]	*F(1,81)=15.0285[.000]
* C:Normality	*CHSQ(2)=323.9554[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 2.6367[.104]	*F(1,92)= 2.6551[.107]

Table A6.3.37 OLS estimation of a real output (DGDPR) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINF(-1)	35.9067	31.1743	1.1518[.253]
DINF(-2)	-1.8935	33.4624	-.0565[.955]
DINF(-3)	-78.5083	32.9804	-2.3805[.020]
DINF(-4)	-61.1796	29.0779	-2.1040[.038]
DGDPR(-1)	-.0752	.1023	-.7358[.464]
DGDPR(-2)	-.1409	.1086	-1.2975[.198]
DGDPR(-3)	.0320	.1104	.2904[.772]
DGDPR(-4)	.3125	.1062	2.9403[.004]
CONST	899.6993	178.4686	5.0412[.000]
S1	-1397.7000	287.7524	-4.8574[.000]
S2	-871.9562	281.4557	-3.0980[.003]
S3	-912.8768	290.0216	-3.1476[.002]

R-Squared = .90594 R-Bar-Squared = .89332
S.E. of Regression = 287.0267 F(11, 82)= 71.7986[.000]
Mean of Dependent Variable = 119.3511 S.D.= 878.7908
Residual Sum of Squares= 6755516 Equation Log-likelihood= -658.9613
AIC = -670.9613 SBC = -686.2210
DW-statistic = 1.9335 System Log-likelihood = -780.6565

Table A6.3.38 Real output (DGDPR) equation diagnostic tests

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(4)= 3.5307[.473]	*F(4,78)= .7610[.554]
* B:Functional Form	*CHSQ(1)= 2.4717[.116]	*F(1,81)=2.1874[.143]
* C:Normality	*CHSQ(2)= 1.8369[.399]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 2.4505[.117]	*F(1,92)=2.4625[.120]

Table A6.3.34 Selecting the order of the bivariate model:
Inflation rate (DINF) vs real output (DGDPR)

Lag order	AIC	SBC	LR test	Adjusted LR test
12	-751.1563	-819.8780	------	------
11	-748.4799	-812.2930	CHSQ(4)= 2.6473[.618]	1.7854[.775]
10	-750.8811	-809.7854	CHSQ(8)= 15.4496[.051]	10.4195[.237]
9	-747.8547	-801.8503	CHSQ(12)= 17.3968[.135]	11.7327[.467]
8	-744.3680	-793.4549	CHSQ(16)= 18.4234[.300]	12.4251[.714]
7	-746.0435	-790.2217	CHSQ(20)= 29.7744[.074]	20.0804[.453]
6	-742.9951	-782.2647	CHSQ(24)= 31.6776[.135]	21.3640[.617]
5	-742.2533	-776.6142	CHSQ(28)= 38.1940[.095]	25.7588[.586]
4	-741.0696	-770.5217	CHSQ(32)= 43.8266[.079]	29.5574[.591]
3	-750.5378	-775.0813	CHSQ(36)= 70.7631[.000]	47.7239[.091]
2	-747.3706	-767.0054	CHSQ(40)= 72.4287[.001]	48.8473[.159]
1	-748.2970	-763.0231	CHSQ(44)= 82.2815[.000]	55.4922[.115]
0	-754.4471	-764.2645	CHSQ(48)= 102.5817[.000]	69.1830[.024]

Table A6.3.35 OLS estimation of inflation rate (DINF) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINF(-1)	-.42541	.10664	-3.9891[.000]
DINF(-2)	-.15996	.11447	-1.3974[.166]
DINF(-3)	-.23738	.11282	-2.1040[.038]
DINF(-4)	-.15486	.099471	-1.5569[.123]
DGDPR(-1)	.9712E-3	.3500E-3	2.7747[.007]
DGDPR(-2)	.00105	.3715E-3	2.8341[.006]
DGDPR(-3)	.2134E-3	.3780E-3	.5646[.574]
DGDPR(-4)	.7621E-3	.3636E-3	2.0961[.039]
CONST	-.92913	.61051	-1.5219[.132]
S1	-.38148	.98435	-.3875[.699]
S2	.88619	.96281	.9204[.360]
S3	1.65810	.99212	1.6713[.098]

R-Squared = .36607 R-Bar-Squared = .28103
S.E. of Regression = .98187 F(11,82)= 4.3047[.000]
Mean of Dependent Variable= -.021596 S.D.= 1.1580
Residual Sum of Squares= 79.0538 Equation Log-likelihood= -125.2414
AIC = -137.2414 SBC = -152.5012
DW-statistic = 2.0257 System Log-likelihood = -780.6565

Table A6.3.36 Inflation rate (DINF) equation diagnostic tests

* Test Statistics	* LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= .3766[.984]	* F(4,78)= .0784[.989]
* B:Functional Form	*CHSQ(1)= 14.7111[.000]	*F(1,81)=15.0285[.000]
* C:Normality	*CHSQ(2)=323.9554[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 2.6367[.104]	*F(1,92)= 2.6551[.107]

Table A6.3.37 OLS estimation of a real output (DGDPR) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DINF(-1)	35.9067	31.1743	1.1518[.253]
DINF(-2)	-1.8935	33.4624	-.0565[.955]
DINF(-3)	-78.5083	32.9804	-2.3805[.020]
DINF(-4)	-61.1796	29.0779	-2.1040[.038]
DGDPR(-1)	-.0752	.1023	-.7358[.464]
DGDPR(-2)	-.1409	.1086	-1.2975[.198]
DGDPR(-3)	.0320	.1104	.2904[.772]
DGDPR(-4)	.3125	.1062	2.9403[.004]
CONST	899.6993	178.4686	5.0412[.000]
S1	-1397.7000	287.7524	-4.8574[.000]
S2	-871.9562	281.4557	-3.0980[.003]
S3	-912.8768	290.0216	-3.1476[.002]

R-Squared = .90594 R-Bar-Squared = .89332
S.E. of Regression = 287.0267 F(11, 82)= 71.7986[.000]
Mean of Dependent Variable = 119.3511 S.D.= 878.7908
Residual Sum of Squares= 6755516 Equation Log-likelihood= -658.9613
AIC = -670.9613 SBC = -686.2210
DW-statistic = 1.9335 System Log-likelihood = -780.6565

Table A6.3.38 Real output (DGDPR) equation diagnostic tests

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(4)= 3.5307[.473]	*F(4,78)= .7610[.554]
* B:Functional Form	*CHSQ(1)= 2.4717[.116]	*F(1,81)=2.1874[.143]
* C:Normality	*CHSQ(2)= 1.8369[.399]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 2.4505[.117]	*F(1,92)=2.4625[.120]

Table A6.3.39 Impulse and cumulative responses:
Real output (DGDPR) vs inflation rate (DINF)

	IMPULSE RESPONSES					
	(a) to inflation rate shock			(b) to real GDP shock		
	DGDPR	DINF	IRD	DGDPR	DINF	IRD
1	-77.28	0.982	-0.10	286.98	-0.265	-0.70
2	40.99	-0.493	-0.11	-31.09	0.391	-9.55
3	-11.56	0.010	-1.47	-23.49	0.148	-4.77
4	-83.20	-0.143	0.76	40.69	-0.056	-1.05
5	-41.52	-0.119	0.46	72.08	0.175	1.84
6	52.58	0.049	1.43	-50.76	-0.077	1.15
7	8.15	0.011	0.94	-20.02	0.013	-0.48
8	-16.88	0.029	-0.78	13.93	-0.052	-2.83
9	-6.69	-0.035	0.25	16.10	0.048	2.25
10	14.38	0.018	1.07	-14.12	-0.016	0.85
11	-0.39	-0.001	0.52	-4.34	0.000	-0.07
12	-6.53	0.002	-4.49	6.65	-0.006	-0.67
13	-0.25	-0.008	0.04	2.78	0.010	2.69
14	4.11	0.004	1.23	-4.40	-0.003	0.51
15	-0.52	0.001	-0.60	-0.89	-0.002	1.90
20	-0.57	-0.001	1.47	0.74	0.000	0.41
25	0.10	0.000	-3.88	-0.05	0.000	-1.42
30	0.01	0.000	0.62	-0.03	0.000	0.87
35	-0.01	0.000	3.80	0.01	0.000	-0.09
40	0.00	0.000	-0.22	0.00	0.000	2.47

	CUMULATIVE RESPONSES					
	(c) to inflation rate shock			(d) to real GDP shock		
	DGDPR	DINF	LRD	DGDPR	DINF	LRD
1	-77.28	0.982	-0.10	286.98	-0.265	-0.70
2	-36.30	0.489	-0.10	255.89	0.127	0.38
3	-47.86	0.500	-0.13	232.39	0.274	0.90
4	-131.06	0.356	-0.48	273.08	0.218	0.61
5	-172.57	0.237	-0.96	345.16	0.393	0.86
6	-119.99	0.286	-0.55	294.40	0.316	0.81
7	-111.84	0.297	-0.50	274.38	0.329	0.91
8	-128.72	0.326	-0.52	288.31	0.277	0.73
9	-135.41	0.291	-0.61	304.41	0.324	0.81
10	-121.03	0.309	-0.52	290.29	0.309	0.81
11	-121.42	0.308	-0.52	285.96	0.309	0.82
12	-127.95	0.309	-0.54	292.61	0.303	0.79
13	-128.20	0.301	-0.56	295.39	0.313	0.80
14	-124.09	0.306	-0.53	291.00	0.310	0.81
15	-124.61	0.307	-0.54	290.11	0.308	0.81
20	-126.04	0.306	-0.54	292.14	0.309	0.80
25	-125.71	0.306	-0.54	291.91	0.309	0.80
30	-125.68	0.306	-0.54	291.84	0.309	0.80
35	-125.70	0.306	-0.54	291.87	0.309	0.80
40	-125.70	0.306	-0.54	291.87	0.309	0.80

Table A6.3.40 Selecting the order of the trivariate VAR model: (DM1, DCPI, DGDPR)

Order	AIC	SBC	LR test	Adjusted LR test
12	-1576.2	-1708.7	------	------
11	-1576.7	-1698.1	CHSQ(9)= 18.9213[.026]	11.0008[.276]
10	-1570.2	-1680.6	CHSQ(18)= 23.9582[.156]	13.9292[.734]
9	-1564.6	-1664.0	CHSQ(27)= 30.7167[.283]	17.8585[.908]
8	-1560.5	-1648.8	CHSQ(36)= 40.5716[.276]	23.5881[.945]
7	-1563.7	-1641.0	CHSQ(45)= 65.0767[.027]	37.8353[.767]
6	-1560.0	-1626.3	CHSQ(54)= 75.6590[.027]	43.9878[.833]
5	-1555.6	-1610.8	CHSQ(63)= 84.8339[.035]	49.3220[.896]
4	-1551.0	-1595.2	CHSQ(72)= 93.5647[.045]	54.3981[.939]
3	-1597.8	-1630.9	CHSQ(81)= 205.1920[.000]	119.2977[.004]
2	-1624.1	-1646.2	CHSQ(90)= 275.7884[.000]	160.3421[.000]
1	-1633.8	-1644.8	CHSQ(99)= 313.2049[.000]	182.0959[.000]
0	-1679.1	-1679.1	CHSQ(108)= 421.7309[.000]	245.1924[.000]

Table A6.3.41 Cointegration test results: (M1, CPI and GDPR)

(with unrestricted intercept and no trend in VAR, order = 7)

(i)Maximal Eigenvalue test

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	18.5183	21.1200	19.0200
r<= 1	r = 2	6.1596	14.8800	12.9800
r<= 2	r = 3	.0039	8.0700	6.5000

(ii) Trace test

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	24.6818	31.5400	28.7800
r<= 1	r>= 2	6.1636	17.8600	15.7500
r<= 2	r = 3	.0039	8.0700	6.5000

(iii) Using Model Selection Criteria

Rank	Maximized LL	AIC	SBC	HQC
r = 0	-1597.9	-1654.9	-1726.8	-1683.9
r = 1	-1588.6	-1650.6	-1728.8	-1682.2
r = 2	-1585.6	-1650.6	-1732.5	-1683.6
r = 3	-1585.6	-1651.6	-1734.8	-1685.1

Note: Eigenvalues = .18232 .064760 .4289E-4

Table A6.3.42 OLS estimation of money (DM1) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-ratio[Prob]
DM1(-1)	-.0808	.12146	-.6655[.508]
DM1(-2)	.0147	.12333	.1192[.905]
DM1(-3)	-.1073	.12219	-.8785[.383]
DM1(-4)	.1752	.11680	1.5003[.138]
DM1(-5)	-.1644	.13711	-1.1994[.234]
DM1(-6)	.0205	.13849	.1487[.882]
DCPI(-1)	6.2711	6.55510	.9566[.342]
DCPI(-2)	.1805	6.98860	.0258[.979]
DCPI(-3)	.1138	6.85700	.0166[.987]
DCPI(-4)	1.1904	7.12640	.1670[.868]
DCPI(-5)	15.3717	7.11000	2.1620[.034]
DCPI(-6)	-12.0584	6.83620	-1.7639[.082]
DGDPR(-1)	.1720	.14003	1.2284[.223]
DGDPR(-2)	-.0166	.14304	-.1167[.907]
DGDPR(-3)	-.3378	.14183	-2.3818[.020]
DGDPR(-4)	.0417	.14465	.2888[.774]
DGDPR(-5)	.1662	.15268	1.0888[.280]
DGDPR(-6)	-.1903	.14574	-1.3061[.196]
CONST	-426.0536	264.59050	-1.6102[.112]
T	4.9895	2.09650	2.3799[.020]
S1	-178.7705	378.49190	-.4723[.638]
S2	840.2089	391.12370	2.1482[.035]
S3	428.1068	354.48910	1.2077[.231]

R-Squared = .53339 R-Bar-Squared = .38461
S.E. of Regression= 332.3615 F(22,69)= 3.5852[.000]
Mean of Dependent Variable= 175.0435 S.D= 423.6781
Residual Sum of Squares= 7622030 Equation Log-likelihood = -651.4815
AIC = -674.4815 SBC = -703.4821
DW-statistic = 2.0239 System Log-likelihood = -1571.6

Table A6.3.43 Money (DM1) equation diagnostic tests

* Test Statistics *	LM Version	F Version
* A:Serial Correlation	*CHSQ(4)= 8.6498[.070]	*F(4,65)= 1.6864[.164]
* B:Functional Form	*CHSQ(1)= 3.5603[.059]	*F(1,68)= 2.7374[.103]
* C:Normality	*CHS(2) = 4.2202[.121]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .8523[.356]	*F(1,90)= .8416[.361]

Table A6.3.44 OLS estimation of price (DCPI) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DM1(-1)	.00125	.00230	.5447[.588]
DM1(-2)	.00204	.00234	.8701[.387]
DM1(-3)	.3145E-3	.00232	.1353[.893]
DM1(-4)	.00179	.00222	.8097[.421]
DM1(-5)	.00177	.00260	.6803[.499]
DM1(-6)	.00276	.00263	1.0511[.297]
DCPI(-1)	.34798	.12466	2.7916[.007]
DCPI(-2)	.21393	.13290	1.6097[.112]
DCPI(-3)	-.03618	.13040	-.2775[.782]
DCPI(-4)	-.04713	.13552	-.3477[.729]
DCPI(-5)	.06677	.13521	.4938[.623]
DCPI(-6)	.08888	.13000	.6837[.496]
DGDPR(-1)	.00356	.00266	1.3370[.186]
DGDPR(-2)	.00543	.00272	1.9997[.049]
DGDPR(-3)	.00123	.00269	.4560[.650]
DGDPR(-4)	.00452	.00275	1.6464[.104]
DGDPR(-5)	.7206E-3	.00290	.2481[.805]
DGDPR(-6)	.1490E-3	.00277	.0537[.957]
CONST	2.44740	5.03170	.4863[.628]
T	-.09878	.03986	-2.4776[.016]
S1	-1.25720	7.19770	-.1746[.862]
S2	2.11920	7.43790	.2849[.777]
S3	10.03790	6.74120	1.4890[.141]

R-Squared = .53014 R-Bar-Squared = .38033
S.E. of Regression = 6.3204 F(22, 69)= 3.5388[.000]
Mean of Dependent Variable = 8.9239 S.D = 8.0291
Residual Sum of Squares= 2756.4 Equation Log-likelihood =-286.9375
AIC = -309.9375 SBC = -338.9381
DW-statistic = 1.9758 System Log-likelihood = -1571.6

Table A6.3.45 Price (DCPI) equation diagnostic tests

* Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 2.0823[.721]	*F(4,65)= .37631[.825]
* B:Functional Form	*CHSQ(1)= 11.9018[.001]	*F(1,68)= 10.1041[.002]
* C:Normality	*CHSQ(2)= 653.6679[.000]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= 13.0841[.000]	*F(1,90)= 14.9219[.000]

Table A6.3.46 OLS estimation of real output (DGDPR) equation in the unrestricted VAR

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
DM1(-1)	.1073	.1046	1.0257[.309]
DM1(-2)	.0215	.1062	.2030[.840]
DM1(-3)	.1182	.1052	1.1229[.265]
DM1(-4)	.0360	.1006	.3586[.721]
DM1(-5)	-.1660	.1181	-1.4060[.164]
DM1(-6)	.0089	.1193	.0752[.940]
DCPI(-1)	5.1061	5.6477	.9041[.369]
DCPI(-2)	-4.8071	6.0212	-.7983[.427]
DCPI(-3)	-13.6437	5.9078	-2.3094[.024]
DCPI(-4)	2.0959	6.1400	.3413[.734]
DCPI(-5)	14.8769	6.1258	2.4286[.018]
DCPI(-6)	-16.2926	5.8899	-2.7662[.007]
DGDPR(-1)	-.1155	.1206	-.9574[.342]
DGDPR(-2)	-.1649	.1232	-1.3380[.185]
DGDPR(-3)	-.0608	.1222	-.4982[.620]
DGDPR(-4)	.2258	.1246	1.8119[.074]
DGDPR(-5)	.0264	.1315	.2008[.841]
DGDPR(-6)	-.1439	.1255	-1.1461[.256]
CONST	978.3423	227.9649	4.2916[.000]
T	-.0878	1.8063	-.0486[.961]
S1	-1364.3000	326.0997	-4.1836[.000]
S2	-639.1422	336.9829	-1.8967[.062]
S3	-959.8197	305.4194	-3.1426[.002]

R-Squared = .91802 R-Bar-Squared = .89188
S.E. of Regression = 286.3548 F(22,69)= 35.1204[.000]
Mean of Dependent Variable= 117.9891 S.D= 870.8617
Residual Sum of Squares = 5657937 Equation Log-likelihood = -637.7743
AIC = -660.7743 SBC = -689.7749
DW-statistic = 2.0282 System Log-likelihood = -1571.6

Table A6.3.47 Real output (DGDPR) equation diagnostic tests

Test Statistics *	LM Version	* F Version
* A:Serial Correlation	*CHSQ(4)= 9.8466[.043]	*F(4,65)= 1.9477[.113]
* B:Functional Form	*CHSQ(1)= 3.1658[.075]	*F(1,68)= 2.4233[.124]
* C:Normality	*CHSQ(2)= .3726[.830]	* Not applicable
* D:Heteroscedasticity	*CHSQ(1)= .2271[.634]	*F(1,90)= .2227[.638]

Table A6.3.48 Trivariate model impulse and cumulative responses (DGDPR, DCPI, DM1)

	IMPULSE RESPONSES								
	(a) to monetary shock			(b) to output shock			('c) to price shock		
	DGDPR	DM1	DCPI	DGDPR	DM1	DCPI	DGDPR	DM1	DCPI
1	29.5	332.4	-0.600	286.3	34.2	-1.794	-81.3	-31.5	6.320
2	29.2	-25.6	0.315	-38.6	35.2	0.439	38.3	28.2	1.870
3	0.7	13.3	0.892	-27.3	-11.3	1.303	-9.5	18.1	1.668
4	44.7	-41.9	0.666	24.7	-95.0	0.725	-88.1	39.1	0.897
5	-2.1	67.3	1.336	51.3	42.2	1.719	-17.9	-29.1	-0.345
6	-64.8	-62.1	1.458	-51.0	44.6	0.859	98.9	98.4	-0.051
7	7.6	19.5	1.480	-39.2	-44.2	0.717	-64.8	8.1	0.675
8	12.4	0.1	0.511	10.0	-13.3	0.151	-30.5	-2.6	0.738
9	-21.7	61.7	0.635	23.5	48.1	0.047	-6.0	-74.6	0.253
10	-33.3	-29.5	0.043	-17.0	37.5	-0.028	14.5	52.9	0.572
15	5.2	-6.3	0.160	-19.7	-34.6	0.024	-13.2	10.0	-0.083
20	6.4	16.3	-0.036	16.5	3.8	-0.012	-8.5	-20.4	0.013
25	-8.5	-3.2	0.016	-0.1	12.8	-0.016	10.1	4.1	-0.002
30	1.2	-5.4	0.006	-7.4	-7.0	0.024	-1.2	6.9	-0.007
35	3.2	3.8	-0.011	3.6	-2.5	-0.006	-4.0	-4.6	0.013
40	-2.0	0.7	0.004	1.7	4.1	-0.008	2.4	-0.9	-0.004

	CUMULATIVE RESPONSES								
	(d) to monetary shock			(e) to output shock			(f) to price shock		
	DGDPR	DM1	DCPI	DGDPR	DM1	DCPI	DGDPR	DM1	DCPI
1	29	332	-0.60	286	34	-1.794	-81	-32	6.32
2	59	307	-0.28	248	69	-1.355	-43	-3	8.19
3	59	320	0.61	220	58	-0.053	-53	15	9.86
4	104	278	1.27	245	-37	0.673	-141	54	10.76
5	102	346	2.61	296	5	2.391	-159	25	10.41
6	37	283	4.07	245	50	3.251	-60	123	10.36
7	45	303	5.55	206	6	3.968	-124	131	11.03
8	57	303	6.06	216	-8	4.119	-155	129	11.77
9	35	365	6.69	240	41	4.166	-161	54	12.03
10	2	335	6.74	223	78	4.138	-146	107	12.60
11	12	343	6.98	181	30	4.439	-169	124	12.54
12	26	362	6.97	203	26	4.504	-192	111	12.84
13	3	378	7.32	216	46	4.450	-182	98	12.69
14	-16	352	7.47	192	64	4.624	-164	128	12.61
15	-11	346	7.63	172	29	4.649	-177	138	12.53
20	-7	375	7.56	196	39	4.483	-195	111	12.76
25	-21	370	7.63	196	55	4.468	-180	119	12.72
30	-19	363	7.64	186	46	4.507	-182	128	12.72
35	-14	368	7.63	191	42	4.503	-187	122	12.75
40	-17	369	7.64	193	48	4.49	-184	120	12.74

APPENDIX 7.2 TESTS ON NEW ZEALAND MONETARY TRANSMISION MODELS

Table A7.2.1 Stability test

Interest rate channel		***Exchange rate channel***		***Other asset price channel***	
Roots of Characteristic Polynomial		Roots of Characteristic Polynomial		Roots of Characteristic Polynomial	
Endogenous variables:		Endogenous variables:		Endogenous variables:	
DM1 DINT DKF DGDPR		DM1 DINT DEXCH DEXPT DGDPR		DM1 DPE DPCE DGDPR	
Exogenous variables: C S1 S2 S3		Exogenous variables: C S1 S2 S3		Exogenous variables: C S1 S2 S3	
Lag specification: 1 7		Lag specification: 1 7		Lag specification: 1 5	
Root	Modulus	Root	Modulus	Root	Modulus
-0.001242 - 0.967630i	0.968	-0.871730 + 0.471586i	0.991	-0.079755 + 0.940448i	0.944
-0.001242 + 0.967630i	0.968	-0.871730 - 0.471586i	0.991	-0.079755 - 0.940448i	0.944
0.376263 - 0.870750i	0.949	-0.011326 - 0.985142i	0.985	-0.537609 + 0.745975i	0.920
0.376263 + 0.870750i	0.949	-0.011326 + 0.985142i	0.985	-0.537609 - 0.745975i	0.920
-0.860110 - 0.391831i	0.945	0.780111 + 0.546000i	0.952	-0.905	0.905
-0.860110 + 0.391831i	0.945	0.780111 - 0.546000i	0.952	0.654702 - 0.578984i	0.874
-0.624343 + 0.661390i	0.910	-0.949430 - 0.030175i	0.950	0.654702 + 0.578984i	0.874
-0.624343 - 0.661390i	0.910	-0.949430 + 0.030175i	0.950	0.259784 + 0.798544i	0.840
0.901582 + 0.049631i	0.903	0.412702 + 0.845896i	0.941	0.259784 - 0.798544i	0.840
0.901582 - 0.049631i	0.903	0.412702 - 0.845896i	0.941	0.781	0.781
0.559338 + 0.664962i	0.869	0.170738 - 0.924270i	0.940	-0.766	0.766
0.559338 - 0.664962i	0.869	0.170738 + 0.924270i	0.940	0.717606 - 0.237443i	0.756
-0.285760 + 0.777210i	0.828	-0.617141 - 0.700422i	0.934	0.717606 + 0.237443i	0.756
-0.285760 - 0.777210i	0.828	-0.617141 + 0.700422i	0.934	-0.482082 + 0.552875i	0.734
0.727975 - 0.343612i	0.805	0.876851 + 0.099619i	0.882	-0.482082 - 0.552875i	0.734
0.727975 + 0.343612i	0.805	0.876851 - 0.099619i	0.882	-0.546527 + 0.253693i	0.603
-0.789722 - 0.153321i	0.804	0.878	0.878	-0.546527 - 0.253693i	0.603
-0.789722 + 0.153321i	0.804	0.610333 + 0.585987i	0.846	0.212710 + 0.551433i	0.591
-0.804	0.804	0.610333 - 0.585987i	0.846	0.212710 - 0.551433i	0.591
-0.527791 - 0.603909i	0.802	-0.231621 + 0.812007i	0.844	0.204	0.204
-0.527791 + 0.603909i	0.802	-0.231621 - 0.812007i	0.844		
0.632133 + 0.436235i	0.768	0.770190 + 0.344727i	0.844		
0.632133 - 0.436235i	0.768	0.770190 - 0.344727i	0.844		
-0.020322 + 0.744853i	0.745	0.513023 + 0.657523i	0.834		
-0.020322 - 0.744853i	0.745	0.513023 - 0.657523i	0.834		
0.102963 + 0.327828i	0.344	-0.650067 + 0.516308i	0.830		
0.102963 - 0.327828i	0.344	-0.650067 - 0.516308i	0.830		
0.137	0.137	-0.441625 - 0.698087i	0.826		
		-0.441625 + 0.698087i	0.826		
		-0.158345 + 0.784544i	0.800		
		-0.158345 - 0.784544i	0.800		
		-0.630466 + 0.280266i	0.690		
		-0.630466 - 0.280266i	0.690		
		-0.472	0.472		
		0.380	0.380		

Table A7.2.1 (Continued)

Credit-investment channel Roots of Characteristic Polynomial Endogenous variables: DM1 DCRED DKF DGDPR Exogenous variables: C S1 S2 S3 Lag specification: 1 5		***Credit-consumption channel*** Roots of Characteristic Polynomial Endogenous variables: DM1 DCRED DPCE DGDPR Exogenous variables: C S1 S2 S3 Lag specification: 1 5	
Root	Modulus	Root	Modulus
0.961	0.961	0.979	0.979
-0.738233 + 0.492719i	0.888	-0.080768 + 0.906311i	0.910
-0.738233 - 0.492719i	0.888	-0.080768 - 0.906311i	0.910
0.004770 - 0.832045i	0.832	-0.886	0.886
0.004770 + 0.832045i	0.832	-0.500800 + 0.681833i	0.846
-0.762737 - 0.200106i	0.789	-0.500800 - 0.681833i	0.846
-0.762737 + 0.200106i	0.789	0.352505 + 0.760906i	0.839
0.123538 - 0.756705i	0.767	0.352505 - 0.760906i	0.839
0.123538 + 0.756705i	0.767	-0.752716 + 0.319122i	0.818
-0.291729 + 0.693426i	0.752	-0.752716 - 0.319122i	0.818
-0.291729 - 0.693426i	0.752	0.520513 - 0.543533i	0.753
0.741	0.741	0.520513 + 0.543533i	0.753
0.398075 + 0.597944i	0.718	0.676703 - 0.093706i	0.683
0.398075 - 0.597944i	0.718	0.676703 + 0.093706i	0.683
0.618	0.618	-0.374289 - 0.506892i	0.630
-0.572561 + 0.206795i	0.609	-0.374289 + 0.506892i	0.630
-0.572561 - 0.206795i	0.609	-0.007798 - 0.517382i	0.517
0.204298 - 0.243858i	0.318	-0.007798 + 0.517382i	0.517
0.204298 + 0.243858i	0.318	-0.485	0.485
-0.045	0.045	0.154	0.154

Table A7.2.2 Serial Correlation test

Interest rate channel			*Exchange rate channel*		
Sample: 1985:1 2002:1			Sample: 1985:1 2002:1		
Lags	LM-Stat	Prob	Lags	LM-Stat	Prob
1	20.4896	0.1990	1	32.2909	0.1498
2	15.8442	0.4639	2	28.0962	0.3034
3	10.5768	0.8348	3	18.6916	0.8117
4	16.5378	0.4161	4	29.1054	0.2595
5	11.2418	0.7943	5	38.8147	0.0384
6	20.1214	0.2148	6	18.5237	0.8194
7	12.5227	0.7073	7	19.7275	0.7610
8	15.2126	0.5091	8	34.1598	0.1045
9	10.2712	0.8521	9	13.1782	0.9742
10	25.7301	0.0579	10	26.8410	0.3639
11	8.4526	0.9342	11	13.2901	0.9727
12	6.2222	0.9855	12	15.7652	0.9216
Probs from chi-square with 25 df.			Probs from chi-square with 25 df.		

Other asset price channel			*Credit-investment channel*		
Lags	LM-Stat	Prob	Lags	LM-Stat	Prob
1	18.7881	0.2798	1	12.1489	0.7337
2	20.3321	0.2056	2	18.9677	0.2703
3	12.0380	0.7414	3	12.3895	0.7168
4	18.7714	0.2807	4	12.5888	0.7026
5	11.6555	0.7673	5	12.5501	0.7053
6	15.5208	0.4869	6	13.9436	0.6029
7	9.9412	0.8697	7	17.4032	0.3600
8	21.1361	0.1733	8	19.9530	0.2223
9	21.9859	0.1436	9	25.1354	0.0675
10	7.6105	0.9596	10	16.7614	0.4012
11	10.4457	0.8423	11	17.2335	0.3706
12	20.7349	0.1889	12	15.2556	0.5060
Probs from chi-square with 16 df.			Probs from chi-square with 16 df.		

Credit-consumption channel

Lags	LM-Stat	Prob
1	11.6406	0.7683
2	15.9335	0.4576
3	7.4974	0.9624
4	16.6081	0.4114
5	8.6102	0.9286
6	16.4722	0.4205
7	6.7994	0.9769
8	9.5059	0.8911
9	24.1618	0.0860
10	20.8778	0.1833
11	16.1855	0.4401
12	6.3397	0.9840
Probs from chi-square with 16 df.		

Table A7.2.3 Heteroscedasticity test

Interest rate channel				*Other asset price channel*			
Joint test:				Joint test:			
Chi-sq	df	Prob.		Chi-sq	df	Prob.	
601.4417	590	0.363		462.6623	430	0.1336	
Individual components:				Individual components:			
Dependent	R-squared	Chi-sq(59)	Prob.	Dependent	R-squared	Chi-sq(43)	Prob.
res1*res1	0.9976	60.8555	0.4089	res1*res1	0.7994	50.3608	0.2051
res2*res2	0.9983	60.8959	0.4075	res2*res2	0.8729	54.9948	0.1038
res3*res3	0.9462	57.7171	0.5229	res3*res3	0.6884	43.3693	0.4556
res4*res4	0.9938	60.6203	0.4172	res4*res4	0.6900	43.4687	0.4513
res2*res1	0.9995	60.9670	0.4050	res2*res1	0.8258	52.0227	0.1628
res3*res1	0.9916	60.4892	0.4218	res3*res1	0.6680	42.0854	0.5109
res3*res2	0.9710	59.2298	0.4671	res3*res2	0.7914	49.8595	0.2193
res4*res1	0.9992	60.9489	0.4057	res4*res1	0.7170	45.1703	0.3814
res4*res2	0.9441	57.5879	0.5277	res4*res2	0.7397	46.6041	0.3264
res4*res3	0.9710	59.2321	0.4670	res4*res3	0.6954	43.8129	0.4368
Credit-investment channel				*Credit-consumption channel*			
Joint test:				Joint test:			
Chi-sq	df	Prob.		Chi-sq	df	Prob.	
439.4640	430	0.3658		426.7643	430	0.5350	
Individual components:				Individual components:			
Dependent	R-squared	Chi-sq(43)	Prob.	Dependent	R-squared	Chi-sq(43)	Prob.
res1*res1	0.6127	38.5973	0.6625	res1*res1	0.6699	42.2060	0.5056
res2*res2	0.7434	46.8338	0.3180	res2*res2	0.6383	40.2144	0.5928
res3*res3	0.7752	48.8406	0.2500	res3*res3	0.6681	42.0917	0.5106
res4*res4	0.7319	46.1103	0.3449	res4*res4	0.6629	41.7616	0.5250
res2*res1	0.4117	25.9374	0.9816	res2*res1	0.4918	30.9831	0.9142
res3*res1	0.8054	50.7376	0.1949	res3*res1	0.5450	34.3334	0.8245
res3*res2	0.7893	49.7270	0.2231	res3*res2	0.7465	47.0283	0.3110
res4*res1	0.6524	41.0986	0.5541	res4*res1	0.7920	49.8952	0.2182
res4*res2	0.7871	49.5863	0.2272	res4*res2	0.8064	50.8040	0.1931
res4*res3	0.8600	54.1786	0.1180	res4*res3	0.7402	46.6310	0.3255

Note: There is not enough data to run the heteroscedasticity test for the exchange rate channel

APPENDIX 7.3 TESTS ON AUSTRALIAN MONETARY TRANSMISION MODELS

Table A7.3.1 Stability test

Interest rate channel		***Exchange rate channel***		***Other asset price channel***	
Roots of Characteristic Polynomial		Roots of Characteristic Polynomial		Roots of Characteristic Polynomial	
Endogenous variables:		Endogenous variables:		Endogenous variables:	
DM1 DINT DKF DGDPR		DM1 DINT DEXCH DEXPT DGDPR		DM1 DPE DPCE DGDPR	
Exogenous variables: C S1 S2 S3		Exogenous variables: C S1 S2 S3		Exogenous variables: C S1 S2 S3	
Lag specification: 1 4		Lag specification: 1 5		Lag specification: 1 4	
Root	Modulus	Root	Modulus	Root	Modulus
0.9817	0.982	-0.517615 + 0.746141i	0.908	0.975	0.975
-0.9086	0.909	-0.517615 - 0.746141i	0.908	-0.961	0.961
-0.247379 - 0.774773i	0.813	0.403193 - 0.790181i	0.887	-0.522188 - 0.733508i	0.900
-0.247379 + 0.774773i	0.813	0.403193 + 0.790181i	0.887	-0.522188 + 0.733508i	0.900
0.675920 - 0.409057i	0.790	0.834487 - 0.213995i	0.861	0.765958 - 0.223956i	0.798
0.675920 + 0.409057i	0.790	0.834487 + 0.213995i	0.861	0.765958 + 0.223956i	0.798
-0.615877 - 0.462118i	0.770	-0.848	0.848	0.131412 - 0.736650i	0.748
-0.615877 + 0.462118i	0.770	0.677610 + 0.478494i	0.830	0.131412 + 0.736650i	0.748
-0.316969 - 0.633348i	0.708	0.677610 - 0.478494i	0.830	-0.714	0.714
-0.316969 + 0.633348i	0.708	-0.805214 + 0.197209i	0.829	-0.419622 + 0.542042i	0.685
0.467130 - 0.480063i	0.670	-0.805214 - 0.197209i	0.829	-0.419622 - 0.542042i	0.685
0.467130 + 0.480063i	0.670	-0.826	0.826	-0.043787 + 0.582636i	0.584
-0.026601 - 0.610225i	0.611	-0.304181 - 0.728916i	0.790	-0.043787 - 0.582636i	0.584
-0.026601 + 0.610225i	0.611	-0.304181 + 0.728916i	0.790	0.287263 + 0.468941i	0.550
-0.5682	0.568	0.096995 + 0.766639i	0.773	0.287263 - 0.468941i	0.550
0.3855	0.386	0.096995 - 0.766639i	0.773	-0.182	0.182
		-0.131383 - 0.755925i	0.767		
		-0.131383 + 0.755925i	0.767		
		-0.626448 - 0.409186i	0.748		
		-0.626448 + 0.409186i	0.748		
		0.695	0.695		
		0.291771 - 0.410286i	0.503		
		0.291771 + 0.410286i	0.503		
		0.372	0.372		
		0.022	0.022		

Table A7.3.1 Stability test (Continued)

Credit- investment channel		***Credit-consumption channel***	
Roots of Characteristic Polynomial Endogenous variables: DM1 DCRED DKF DGDPR Exogenous variables: C S1 S2 S3 Lag specification: 1 5		Roots of Characteristic Polynomial Endogenous variables: DM1 DCRED DPCE DGDPR Exogenous variables: C S1 S2 S3 Lag specification: 1 4	
Root	Modulus	Root	Modulus
0.985	0.985	0.988	0.988
-0.920	0.920	-0.956	0.956
0.818609 - 0.163341i	0.835	-0.535134 - 0.744348i	0.917
0.818609 + 0.163341i	0.835	-0.535134 + 0.744348i	0.917
-0.542045 - 0.591880i	0.803	0.816424 + 0.186375i	0.837
-0.542045 + 0.591880i	0.803	0.816424 - 0.186375i	0.837
-0.195207 - 0.748957i	0.774	0.113031 - 0.741492i	0.750
-0.195207 + 0.748957i	0.774	0.113031 + 0.741492i	0.750
0.502813 - 0.522699i	0.725	0.053884 + 0.579864i	0.582
0.502813 + 0.522699i	0.725	0.053884 - 0.579864i	0.582
0.268856 - 0.662388i	0.715	-0.553559 - 0.088150i	0.561
0.268856 + 0.662388i	0.715	-0.553559 + 0.088150i	0.561
0.086542 + 0.640141i	0.646	0.317357 + 0.328660i	0.457
0.086542 - 0.640141i	0.646	0.317357 - 0.328660i	0.457
-0.384981 + 0.496620i	0.628	-0.132084 + 0.396085i	0.418
-0.384981 - 0.496620i	0.628	-0.132084 - 0.396085i	0.418
-0.542	0.542		
0.375	0.375		
-0.337064 + 0.038359i	0.339		
-0.337064 - 0.038359i	0.339		

Table A7.3.2 Serial correlation test

Interest rate channel

Sample: 1985:1 2002:1

Lags	LM-Stat	Prob
1	21.0839	0.1753
2	21.6527	0.1548
3	21.7907	0.1501
4	12.6840	0.6957
5	6.3358	0.9840
6	22.0144	0.1427
7	19.7932	0.2297
8	19.8783	0.2258
9	17.1697	0.3747
10	14.3737	0.5709
11	6.8301	0.9764
12	10.2169	0.8551

Probs from chi-square with 16 df.

Exchange rate channel

Sample: 1985:1 2002:1

Lags	LM-Stat	Prob
1	35.7523	0.0754
2	24.4871	0.4914
3	31.3632	0.1773
4	16.2007	0.9087
5	24.3116	0.5014
6	15.3300	0.9333
7	15.8886	0.9181
8	27.8641	0.3141
9	20.7039	0.7090
10	26.4502	0.3839
11	25.5885	0.4298
12	22.0188	0.6347

Probs from chi-square with 25 df.

Other asset price channel

Sample: 1985:1 2002:1

Lags	LM-Stat	Prob
1	12.9410	0.6771
2	14.2284	0.5817
3	23.2393	0.1075
4	7.2837	0.9674
5	14.0126	0.5978
6	18.2032	0.3121
7	7.3915	0.9650
8	13.7338	0.6185
9	16.0710	0.4480
10	13.7963	0.6139
11	13.4083	0.6427
12	11.4339	0.7819

Probs from chi-square with 16 df.

Credit-investment channel

Sample: 1985:1 2002:1

Lags	LM-Stat	Prob
1	12.4982	0.7090
2	13.6599	0.6240
3	16.2361	0.4366
4	14.5322	0.5591
5	23.6060	0.0985
6	19.4780	0.2447
7	21.3576	0.1652
8	11.2122	0.7962
9	11.7586	0.7604
10	15.4859	0.4894
11	15.2343	0.5076
12	15.4590	0.4913

Probs from chi-square with 16 df.

Credit-consumption channel

Sample: 1985:1 2002:1

Lags	LM-Stat	Prob
1	13.1864	0.6591
2	9.6405	0.8847
3	22.5721	0.1257
4	10.2280	0.8545
5	12.3610	0.7188
6	18.4678	0.2972
7	13.2110	0.6573
8	15.7977	0.4672
9	25.6394	0.0593
10	17.4135	0.3593
11	22.9289	0.1156
12	15.0631	0.5200

Probs from chi-square with 16 df.

Table A7.3.3. Heteroscedasticity test

Interest rate channel

Joint test:

Chi-sq	df	Prob.
353.1771	350	0.4424

Individual components:

Dependent	R-squared	Chi-sq(35)	Prob.
*res1*res1*	0.5133	32.8534	0.5721
*res2*res2*	0.8021	51.3372	0.0368
*res3*res3*	0.3543	22.6722	0.9465
*res4*res4*	0.6631	42.4406	0.1810
*res2*res1*	0.5389	34.4872	0.4927
*res3*res1*	0.4996	31.9726	0.6150
*res3*res2*	0.5206	33.3209	0.5493
*res4*res1*	0.6536	41.8286	0.1985
*res4*res2*	0.6875	43.9979	0.1416
*res4*res3*	0.5589	35.7728	0.4320

Exchange rate channel

Joint test:

Chi-sq	df	Prob.
807.1688	795	0.3744

Individual components:

Dependent	R-squared	Chi-sq(53)	Prob.
*res1*res1*	0.8112	50.2932	0.5802
*res2*res2*	0.9560	59.2738	0.2575
*res3*res3*	0.8885	55.0898	0.3955
*res4*res4*	0.9534	59.1116	0.2623
*res5*res5*	0.9399	58.2722	0.2876
*res2*res1*	0.9380	58.1538	0.2913
*res3*res1*	0.8051	49.9170	0.5950
*res3*res2*	0.9782	60.6467	0.2195
*res4*res1*	0.9184	56.9436	0.3306
*res4*res2*	0.9092	56.3705	0.3501
*res4*res3*	0.8529	52.8787	0.4789
*res5*res1*	0.9361	58.0394	0.2949
*res5*res2*	0.9664	59.9162	0.2392
*res5*res3*	0.9185	56.9500	0.3304
*res5*res4*	0.8639	53.5614	0.4526

Other asset price channel

Joint test:

Chi-sq	df	Prob.
371.0793	350	0.2100

Individual components:

Dependent	R-squared	Chi-sq(35)	Prob.
*res1*res1*	0.4424	28.3122	0.7810
*res2*res2*	0.5825	37.2805	0.3646
*res3*res3*	0.6091	38.9835	0.2952
*res4*res4*	0.6819	43.6425	0.1499
*res2*res1*	0.4423	28.3055	0.7813
*res3*res1*	0.6061	38.7915	0.3026
*res3*res2*	0.4339	27.7697	0.8026
*res4*res1*	0.6030	38.5930	0.3104
*res4*res2*	0.6738	43.1263	0.1627
*res4*res3*	0.6933	44.3688	0.1332

Credit-consumption channel

Joint test:

Chi-sq	df	Prob.
454.3193	430	0.2014

Individual components:

Dependent	R-squared	Chi-sq(43)	Prob.
*res1*res1*	0.7644	48.1560	0.2721
*res2*res2*	0.8194	51.6217	0.1724
*res3*res3*	0.7660	48.2559	0.2688
*res4*res4*	0.7807	49.1824	0.2394
*res2*res1*	0.7921	49.9002	0.2181
*res3*res1*	0.7357	46.3477	0.3359
*res3*res2*	0.5911	37.2365	0.7187
*res4*res1*	0.7542	47.5115	0.2940
*res4*res2*	0.6553	41.2831	0.5460
*res4*res3*	0.7050	44.4123	0.4120

Credit consumption channel

Joint test:

Chi-sq	df	Prob.
380.6019	350	0.1252

Individual components:

Dependent	R-squared	Chi-sq(35)	Prob.
*res1*res1*	0.4957	31.7271	0.6269
*res2*res2*	0.4971	31.8126	0.6228
*res3*res3*	0.6014	38.4927	0.3144
*res4*res4*	0.7679	49.1455	0.0568
*res2*res1*	0.4304	27.5475	0.8111
*res3*res1*	0.6393	40.9158	0.2268
*res3*res2*	0.6635	42.4614	0.1804
*res4*res1*	0.6964	44.5695	0.1289
*res4*res2*	0.6018	38.5182	0.3134
*Res4*res3*	0.5750	36.8027	0.3854

Table A7.3.4 Exchange rate regression

Dependent Variable: DEXCH
Method: Least Squares
Date: 02/05/04 Time: 12:30
Sample(adjusted): 1985:2 2002:1
Included observations: 68 after adjusting endpoints
DEXCH=C(1)+C(2)*DINT+C(3)*DM1+C(4)*DEXPT+C(5)*DGDPR

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.001281	0.003103	-0.412888	0.6811
C(2)	0.006018	0.003408	1.765995	0.0822
C(3)	4.85E-06	7.14E-06	0.678931	0.4997
C(4)	1.37E-06	7.16E-06	0.191045	0.8491
C(5)	-3.46E-06	3.50E-06	-0.988286	0.3268

R-squared	0.065876	Mean dependent var	-0.001412
Adjusted R-squared	0.006567	S.D. dependent var	0.023045
S.E. of regression	0.022969	Akaike info criterion	-4.63862
Sum squared resid	0.033238	Schwarz criterion	-4.475421
Log likelihood	162.7131	Durbin-Watson stat	2.139712

APPENDIX 7.4 COUNTERFACTUAL ANALYISIS

Table A7.4.1 Cointegration test for New Zealand model (DM1, DINT, DGDPR, DCPI)

Trace test				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.5971	95.8004	47.21	54.46
At most 1 **	0.3531	38.5317	29.68	35.65
At most 2	0.1498	11.0887	15.41	20.04
At most 3	0.0136	0.8612	3.76	6.65
Maximum eigenvalue test				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.5971	57.2687	27.07	32.24
At most 1 **	0.3531	27.4430	20.97	25.52
At most 2	0.1498	10.2275	14.07	18.63
At most 3	0.0136	0.8612	3.76	6.65

Table A7.4.2 Serial correlation test for New Zealand model

Lags	LM-Stat	Prob
1	17.7283	0.3400
2	10.3698	0.8466
3	18.1944	0.3126
4	21.7331	0.1520
5	16.5534	0.4150
6	16.4239	0.4238
7	10.6078	0.8330
8	20.1428	0.2139
9	23.2182	0.1080
10	21.0193	0.1778
11	7.1197	0.9709
12	10.5061	0.8389

Note: Probs from chi-square with 16 df.

Table A7.4.3 Heteroscedasticity test for New Zealand model

Joint test:

Chi-sq	df	Prob.
572.8906	550	0.2417

Individual components:

Dependent	R-squared	F(55,6)	Prob.	Chi-sq(55)	Prob.
Res1*res1	0.9205	1.2637	0.4194	57.0731	0.3980
Res2*res2	0.9273	1.3918	0.3636	57.4937	0.3830
Res3*res3	0.9370	1.6228	0.2836	58.0946	0.3620
Res4*res4	0.9649	2.9983	0.0836	59.8234	0.3049
Res2*res1	0.9778	4.7994	0.0273	60.6221	0.2803
Res3*res1	0.8515	0.6256	0.8349	52.7933	0.5594
Res3*res2	0.9523	2.1769	0.1648	59.0412	0.3301
Res4*res1	0.9408	1.7330	0.2530	58.3284	0.3540
Res4*res2	0.9374	1.6325	0.2808	58.1164	0.3613
Res4*res3	0.9447	1.8625	0.2222	58.5695	0.3459

Table A7.4.4 Cointegration test for Australian model (DM1, DINT, DGDPR, DCPI)

Trace test				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.4379	80.1746	47.21	54.46
At most 1 **	0.4088	43.8759	29.68	35.65
At most 2	0.0951	10.7589	15.41	20.04
At most 3 *	0.0683	4.4593	3.76	6.65
Maximum eigenvalue test				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.4379	36.2986	27.07	32.24
At most 1 **	0.4088	33.1169	20.97	25.52
At most 2	0.0951	6.2996	14.07	18.63
At most 3 *	0.0683	4.4592	3.76	6.65

Notes: Observations = 63; trend assumption =linear deterministic trend
Lag interval: 1 to 5

Table A7.4.5 Serial correlation test for Australian model

Lags	LM-Stat	Prob
1	14.0742	0.5932
2	14.1432	0.5880
3	11.5476	0.7745
4	25.7224	0.0581
5	14.6875	0.5476
6	12.0278	0.7421
7	8.0875	0.9462
8	19.3117	0.2528
9	15.5259	0.4865
10	19.5229	0.2425
11	16.7322	0.4031
12	14.6269	0.5521

Probs from chi-square with 16 df.

Table A7.4.6 Heteroscedasticity test for Australian model

Joint test:

Chi-sq	df	Prob.
538.2512	550	0.6318

Individual components:

Dependent	R-squared	F(55,6)	Prob.	Chi-sq(55)	Prob.
res4*res4	0.8193	0.4945	0.9219	50.7941	0.6360
res2*res1	0.9320	1.4962	0.3246	57.7866	0.3727
res3*res1	0.9737	4.0428	0.0416	60.3710	0.2879
res4*res1	0.9027	1.0117	0.5579	55.9650	0.4384
res4*res2	0.9451	1.8791	0.2186	58.5980	0.3449
res4*res3	0.7818	0.3908	0.9706	48.4698	0.7207